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ZONATION OF VEGETATION WITHIN THE TULAROSA BASIN, NEW MEXICO[1]

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ABSTRACT. The vegetation on two unusual substrates (lava and gypsum sand) is compared, and causative factors influencing distribution are discussed.

The Tularosa Basin in south central New Mexico provides a situation which illustrates the interaction of several rigorous environmental factors in determining plant distribution. The north central part of the basin is an arid valley upon which two strikingly contrasting smaller environments are superimposed. One, a deposit of drifting gypsum, the Alamogordo White Sands, lies in the lowest part of the basin at the site of a Quaternary lake. The other, a lava bed, the Carrizozo "malpais" or "badlands," believed to have been extruded within the past one thousand years, parallels the main axis of the basin, approximately the northern two-thirds lying within the Upper Sonoran and the lower third with the Lower Sonoran Zone. The lava flow extends at the southern tip to within 15 miles of the gypsum sand.

The present paper analyzes the several causal factors determining plant distribution in the gypsum deposit, the neighboring lava flow to the north, and the alkaline plain surrounding these two areas.

PHYSIOGRAPHY AND CLIMATE. — Bounded on the south by a low divide and on the three remaining sides by mountains, the Tularosa Basin is an internal drainage area approximately 40 miles wide with a long axis extending north and south for 150 miles. There are no permanent lakes or streams, flood waters discharged from the mountains being absorbed by the highly porous gypseous soil. The water table of the basin floor varies from 25 to more than 100 feet deep except in a small area west of the lava where it lies at around 200 feet (Meinzer and Hare, 1915). Somewhat west of the southern tip of the lava water emerges from the margin as the gypseous Malpais Spring.

Annual precipitation varies with altitude, over a period of 23 years averaging 8.20 inches at 4,156 feet between the gypsum bed and the southern tip of the lava, but for the same period amounting to 11.37 inches at Carrizozo along the east margin of the lava toward the norther tip at an altitude of 5,438 feet (Benson, 1933).

[1] This study was subsidized by a grant from National Science Foundation.

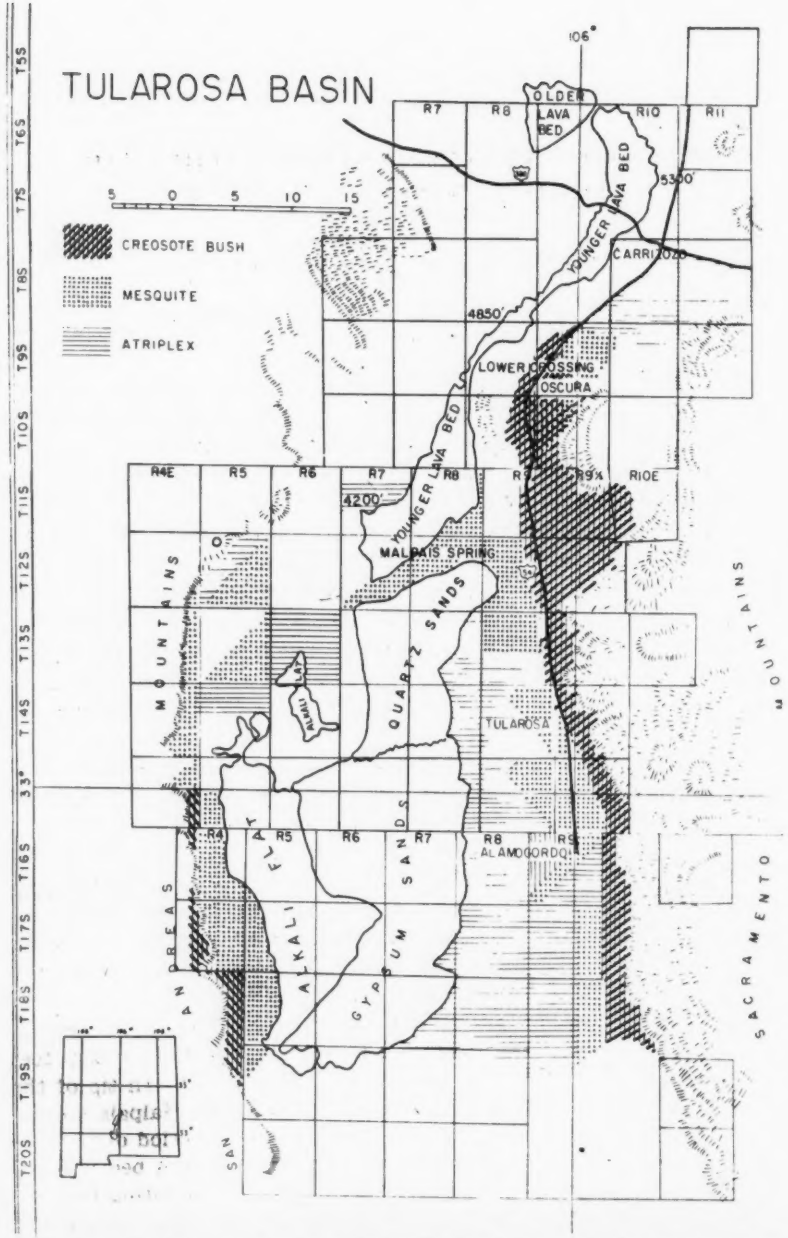

Fig. 1. Central and northern Tularosa Basin, New Mexico (location in the state shown by inset at lower left), with areas of Alamogordo gypsum sand deposit, Carrizozo lava flow, and principal vegetation types.

The gypsum deposit, which is around 97 percent calcium sulfate, covers an area approximately 28 miles long and 8 to 10 miles wide to a depth of around 1000 feet. Gypsum dunes 20 to 50 feet high alternate with narrow, wind-formed depressions. The water table in the flats lies 2 to 3 feet below the surface, and the pH of the substrate is 7.5.

The smaller and much earlier of the two lava flows, covering approximately 25 square miles toward the northern part of the Tularosa Basin, will not be considered here because it is largely revegetated. The younger, more extensive volcanic extrusion flowed southward from near the older deposit, filling a narrow valley ½ to 5 miles wide and 44 miles long to a maximum depth of 70 feet toward the center and 10 to 20 feet along the margin. Most of the surface, covering approximately 120 square miles, exposes rough, unweathered basalt lacking any accumulation of soil except in the crevices, sinkholes and other depressions.

Previous Studies of Vegetation of the Tularosa Basin.—Wooton and Standley collected from many parts of the Tularosa Basin, particularly the White Sands, in connection with the preparation of a state flora (1915), but did not designate any species as growing within the Carrizozo lava flow. Benson (1933), Dice (1940) and Blair (1943), making observations on mammals of the Tularosa Basin, referred to certain plant species as belonging to particular associations and contributed substantially to an understanding of the ecology of the general region. Emerson (1935) observed the distribution of the vegetation within the gypsum deposit and noted the mechanism of survival in the 8 plant species which by meristematic activity of the stem tips resist burial within the dunes. Schaffner (1948) made the first taxonomic study of the White Sands flora. Shields observed modifications in leaf anatomy (1951) and gross plant structure (1953) in species of this habitat. Shields and Mangum considered leaf nitrogen in relation to total soil nitrite and nitrate and to leaf structure in vegetation of the White Sands (1954). Shields and Crispin (1956) compared the distribution of plant species on that part of the lava flow within the Upper Sonoran Zone with that in the Lower Sonoran Zone.

Observations

The distribution for 228 plant species collected over a period of two years within the northern half of the Tularosa Basin is summarized below in Table I. This table is based upon the four lists of species names given at the conclusion of this paper. In each list the genera and species are arranged alphabetically under the family name. Herbarium specimens of all plants collected are deposited at New Mexico Highlands University.

Table I. DISTRIBUTION OF PLANT SPECIES WITHIN THE NORTH CENTRAL TULAROSA BASIN

		Number of species
a.	in gypsum sand but not in lava flow	39
b.	in lava flow but not in gypsum sand	111
c.	common to both environments	23
	Total for gypsum sand *(a* plus *c)*	62
	Total for lava flow *(b* plus *c)*	134
d.	on surrounding plain within 10 mile radius, but not in gypsum sand	38
e.	common to gypsum sand and surrounding alkaline plain	26
f.	in gypsum sand but not on surrounding plain	36
	Total for surrounding plain within 10-mile radius of White Sands *(d* plus *e)*	64
g.	on surrounding plain within 10 mile radius, but not within lava	33
h.	common to lava flow and surrounding plain (exclusive of 17 grasses known to grow within lava, but occurrence outside not determined)	28
i.	in lava but not on surrounding plain within radius of 10 miles (exclusive of grasses)	89
	Total for surrounding plain within 10-mile radius of lava (exclusive of all grasses but 4) *(g* plus *h)*	61
j.	along roadsides within lava but not on surrounding plain except along roadsides or washes	10

VEGETATION OF THE BASIN FLOOR SURROUNDING THE WHITE SANDS AND THE LAVA FLOW. —Proceeding on the floor of the Tularosa Basin toward the mountains to the east or west, the White Sands gypsum deposit and the adjacent alkali flat are surrounded in order by successive bands of saltbush, mesquite and creosote bush (Fig. 1). The saltbush association to the east extends an average of 5 miles out from the gypsum, covering low areas toward the center of the basin where salts from flood waters out of the surrounding mountains have accumulated, producing a soil salinity which exercises a strongly selective action on vegetation. This atriplex association is bordered by a band of mesquite of approximately the same width. Creosote bush farther to the east and west in places forms a zone several miles wide along the mountain slopes and to the north terminates around the midline of the lava flow. In any one of these associations, other species are so few as to be scarcely noticeable except along washes or roadsides. As a rule the creosote bushes, like the mesquite shrubs, are widely separated, large patches of barren soil intervening between individual plants (Fig. 2) as a result of toxic root excretions (Went, 1955).

While 64 species were collected from the plain surrounding the gypsum sand and 62 species, exclusive of grasses, from the plain around the lava flow 15 miles to the north, the two lists have only 23 species in common (List II compared to List III). Vegetation of the plain surrounding the lava flow (62 species) is much less diverse than

that within the lava (134 species), while no comparable contrast exists between the variety within and outside the gypsum area.

VEGETATION OF THE GYPSUM SAND.—The White Sands vegetation consists largely of species capable of adjusting temporarily or permanently to a moving, drifting substrate (Fig. 3). One gymnosperm, 48 dicotyledons and 13 monocotyledons appear in the sparse fringe of typically desert or halophytic vegetation along the bases of marginal dunes and in peripheral flats. Only one species, *Populus wislizeni*, attains tree-like proportions; 11 dicotyledons and one gymnosperm, *Ephedra torreyana*, are shrubs; and the monocotyledons include 11 grasses, 1 rush, and the shrubby *Yucca elata*.

By meristemtaic activity of the stem tips 8 perennials growing in the marginal dunes survive almost complete burial: *Rhus trilobata, Poliomintha incana, Yucca elata, Ephedra torreyana, Populus wislizeni, Atriplex canescens, Chrysothamnus nauseosus* var. *latisqua-*

Fig. 2. Typical growth of creosote bush *(Larrea tridentata)*, the widely spaced plants on coarse gravelly or rocky soil forming a band along the mountain slopes to the east and west of the central and northern Tularosa Basin.

meus and *Comandra pallida*. The first 4 of these species remain in the outer, younger interdunal depressions, anchoring sand in hummocks in the wake of moving drifts. A number of additional species, other than these 8, become temporarily established in the dunes by germination at times when moisture is relatively abundant. Most other species which are to be found within the gypsum area appear sporadically in the outer flats with the exception of *Juncus mexicanus* and *Eustoma exaltatum*, which grow only in a low, moist spot along the east periphery, and *Baccharis glutinosa* and *Distichlis spicata*, which are localized within a slightly greater surrounding area. Two miles to the interior no vegetation survives on the moving dunes except *Poliomintha incana*, *Populus wislizeni* and *Rhus trilobata*, but several additional species grow in small hummocks elevated slightly above the surface of the flats.

Oryzopsis hymenoides and *Abronia angustifolia*, an annual, are the only species which survive in the older interdunal depressions farthest within the sands. *A. angustifolia* does not grow within the lava, and

Fig. 3. Typical growth of *Yucca elata* and *Poliomintha incana* in a peripheral interdunal depression of the Alamogordo gypsum sand deposit.

O. hymenoides is found there only infrequently. Five species growing in the gypsum, ***Frankenia jamesii, Nama carnosum, Greggia linearifolia, Selinocarpus chenopodioides*** and *Bouteloua breviseta,* are considered specific indicators of gypsum (Wooton and Standley, 1915) and are not commonly found in quartz sand deposits. Of these 5 species, none grow on the surrounding plain, and only *F. jamesii* occurs within the lava. While *Prosopis juliflora* var. *glandulosa* serves as a nucleus for quartz sand dune formation in southern New Mexico and grows where gypsum spills over the desert plain adjacent to the White Sands, it does not survive in even the younger gypsum dunes or intervening flats. ***Andropogon scoparius, Sporobolus cryptandrus, Sphaeralcea incana,*** and different species of *Aristida, Oryzopsis* and *Oenothera* than grow in the White Sands are drift-tolerant species of quartz sand deposits which also grow in the gypsum area.

Larrea tridentata, creosote bush, is conspicuously absent from the gypsum as well as from the immediately surrounding alkali flat, though this part of the Tularosa Basin is in the Lower Sonoran Zone,

Fig. 4. *Dasylirion wheelerii* (in flower), *Opuntia imbricata,* and grasses characteristic of lava depressions on that part of the Carrizozo lava flow within the Upper Sonoran Zone.

which is commonly designated as the creosote bush zone. Legumes are conspicuously absent from the gypsum deposit while the number of species of Compositae (16) and Gramineae (11) is relatively high.

Of the 47 dicotyledon species listed by Wooton and Standley (1915) for the White Sands, at least 10 are not at present found within the area. The following additional species listed for the marginal dunes and flats by earlier workers have not been observed in the White Sands between the beginning of the dry cycle in 1950 and the present date: *Cevallia sinuata, Cryptanthe fulvocanescens, Gaura coccinea, Ipomoea hirsutula, Nama hispidum, Pectis angustifolia, Perezia nana,* and *Sartwellia flaveriae.* On the other hand, recent invaders of the marginal dunes include *Haplopappus heterophyllus, Lepidium montanum* var. *alyssoides, Lycium torreyi, Solanum elaeagnifolium* and *Tidestromia lanuginosa.*

VEGETATION OF THE LAVA FLOW.—Compared to the surrounding plain, the crevices and other depressions of the malpais (Fig. 4) support a more diversified flora as to total number of species and in that a greater variety can be seen in any direction. Of the 134 species within the lava flow, 28, exclusive of grasses, grow on the marginal plain, and 20 occur along the roadsides within the lava. Other than the 20 grasses within the lava, 85 species occur only on the northern half, which lies definitely within the Upper Sonoran Zone, while 14 species were collected only from the southern third within the Lower Sonoran Zone, 14 are common to both zones, and one species was found only in the overlap area. At the higher altitude toward the northern tip, the surface is forested by *Juniperus monosperma,* which extends within the lava to a point 10 miles below Carrizozo. This is farther southward and to a lower elevation than this species occurs on the surrounding plain. Certain species characteristic of both zones extend into the overlap area where *J. monosperma,* an Upper Sonoran Zone indicator, occurs sporadically among a scattering growth of *Prosopis juliflora* var. *glandulosa* and *Larrea tridentata,* two Lower Sonoran Zone indicators.

The plant species most prominent within the lava, other than grasses, on the northern half within the Upper Sonoran Zone are *Juniperus monosperma, Dasylirion wheeleri, Nolina microcarpa, Yucca baccata, Berberis haematocarpa, Brickellia californica, Dalea formosa, Artemisia dracunculus* var. *glauca,* and *Psilostrophe tagetina. Prosopis juliflora* var. *glandulosa* and *Larrea tridentata* are prominent on the southern third of the lava. Eight species are conspicuous throughout the volcanic flow: *Atriplex canescens, Celtis reticulata, Fallugia paradoxa, Opuntia engelmannii, O. imbricata, Polanisia uniglandulosa, Rhus trilobata* and *Senecio longilobus.* Of 19 species prominent in the

lava, only 2, *R. trilobata* and *A. canecens*, also occur in the gypsum.

Three large semi-succulents, *Dasylirion*, *Nolina* and *Yucca*, one species of each of which is widely distributed within the lava, and the succulent opuntias, occur as post climaxes on escarpments, talus slopes and rocky hills from western Texas to Mexico and eastern California. *Yucca baccata*, particularly characteristic of that part of the lava within the Upper Sonoran Zone, is found only sporadically while *Y. elata* in places grows thickly marginal to the lava, but is not found within the lava flow. *Opuntia engelmannii* and *O. imbricata*, early invaders of disturbed rangeland which become established through fragmentation, occur more frequently than other cacti on the surrounding plain as well as throughout much of the volcanic deposit. *Distichlis spicata*, *Typha latifolia*, *Clappia suaedifolia* and *Scirpus americanus*, absent from the lava proper, appear conspicuously somewhat west of the southern tip where Malpais Spring forms a pool from which an overflow covers an area about a mile long and 300 yards wide.

The 3 fern species, *Cheilanthes feei*, *Notholaena standleyi* and *Pellaea longimucronata*, along with *Senecio quaerens* and *Clematis ligusticifolia*, grow exclusively in sinkholes or deep crevices, usually appearing from wall niches rather than at the bottom of the depression subject to flooding. Many other herbaceous species, particularly the grasses and *Eriogonum* spp., sometimes grow in crevices and sinkholes, usually on the dirt-filled floor, but occur more frequently as a less luxuriant growth in shallow pockets of earth on the lava surfaces. *Rhus trilobata* and *Brickellia californica* are shrubs characteristic of lava surfaces, particularly in the northern half of the flow, which sometimes also grow from crevices. The 12 species forming a sparse growth within the crater appear also in the surrounding lava. The crater at present is filled with cinders and small amounts of wind-blown soil rather than volcanic ash.

The largest observed kipouka, a small island covering several acres approximately 10 miles south of the crater, supports a more abundant growth of the same vegetation as on the surrounding lava plus 3 additional species, *Populus wislizeni*, *Tamarix gallica* and *Marrubium vulgare*. The several *P. wislizeni* trees on this island grow near a shallow well where the water stands within 6 feet of the surface, but this species is not found elsewhere within the lava nor on the immediately surrounding plain. *Tamarix gallica* was observed only at this site in that part of the lava flow within the Upper Sonoran Zone, but in the sapling stage appears occasionally above Malpais Spring. The only stand of *Marrubium vulgare* was on this kipouka at the site of an old goat corral, but the plant was observed once along a roadside within the lava. This species is usually found in places where sheep or goats are kept.

Discussion

Going northward from the southern tip of the lava flow, precipitation increases 3 inches with an increase in altitude of around 1400 feet over a distance of about 44 miles. From the tip of the lava southward, however, all parts of the central Tularosa Basin are about equally arid except for (a) localized accumulations of water as at Lake Lucero, the pool at Malpais Spring or the wet bottom soil along the east margin of the gypsum sand; and (b) the variable depth of the water table, ranging from 3 feet below the surface of flats in White Sands to around 100 feet, and rarely 200 feet, farther north. In the absence of extreme alkalinity the incidence of the cottonwood, growing in both the White Sands and the lava, depends upon a shallow water table. *Scirpus* spp., *Typha* spp., *Eustoma exaltatum* and *Distichlis spicata* require water standing at or near the surface.

Vegetation of the northern half of the Tularosa Basin floor.— The combination of aridity and soil alkalinity of the central Tularosa Basin floor eliminates many of the species which grow in moist canyons of the San Andreas and Sacramento Mountains on either side. This intervening plain supports, instead, a highly localized flora which in places resembles the Chihuahuan desert association to the south.

Along the main axis of the basin floor on that half extending northward from the White Sands for approximately 83 miles, only 102 plant species were collected (41 surrounding the gypsum deposit, 38 surrounding the lava flow and 23 common to the plains adjacent to both areas). The effect of salinity as distinct from aridity is apparent in the concentric zonation of atriplex, mesquite and creosote bush associations in the lowest part of the basin where the water table is relatively shallow. Expressed as parts per million, total soil solids range from 1,670 to 15,600 and average 4,371 where the water table is less than 25 feet, and range from 502 to 4,267 and average 2,017 p.p.m. where the water table is over 100 feet deep (Meinzer and Hare, 1915). The soils of the Tularosa Basin floor are typical white alkali, containing large amounts of calcium and sulfates, but yielding a solution essentially free of sodium carbonates or bicarbonates, which constitute the harmful black alkali. Water containing more than 1000 p.p.m. white alkali can be used for irrigation only when effective drainage for the removal of alkali is possible. The extreme porosity of the soils of the Tularosa Basin is undoubtedly significant in the escape of alkaline salts and the resulting growth of vegetation. Gypsum has an ameliorating effect on alkali salts (Kearney and Cameron, 1902), which explains why a number of plant species grow in Tularosa Basin

in amounts of toxic salts generally considered beyond the limits of tolerance.

VEGETATION OF THE WHITE SANDS.—Within the White Sands the selective action of drifting gypsum and a soil solution which is saturated calcium sulfate have combined to eliminate 38 species common in the surrounding country. The shallow water table in the flats, however, is responsible for the incidence of cottonwoods and apparently a number of other species which are not found on the surrounding plain. Plants surviving in the moving dunes are mainly those which by meristematic activity elongate beyond the accumulating sand and send out adventitious roots at any level where the stem is covered by moist earth. While the halophytes *Abronia angustifolia, Atriplex canescens, Distichlis spicata* and *Sporobolus airoides* grow within the gypsum deposit, the non-succulent *Eurotia lanata* and the succulent *Allenrolfea occidentalis,* halophytes which have seeded into the lava flow, are apparently not sufficiently dune-tolerant to survive the drifting gypsum. The influence of other factors than dune tolerance on survival within the gypsum is evidenced by the absence of a number of species characteristic of quartz sand dunes. Those species in the flats show no specific adaptations to wind action, but escape extinction mainly by seed propagation. The high concentration of calcium sulfate appears to favor the 5 gypsum indicator species occurring within the White Sands but not in the surrounding area.

Most of the species present in the gypsum bed but not on the surrounding plain appear to have seeded in from the nearby mountains without having become established on the intervening basin floor. Failure of germination does not appear to be an important selective factor in the White Sands since most seeds germinate readily in the moist gypsum of the flats. Even watermelon seeds left by picnickers germinate, and the plants survive well through the seedling stage.

VEGETATION OF THE CARRIZOZO LAVA FLOW.—The barrenness of the greater part of the surface of this recent volcanic flow is attributable to a lack of soil and soil moisture. The rate of soil formation depends to a large extent upon rainfall and the length of the growing season. As a result of the sinkholes and the interlacing crevices which efficiently collect and retain moisture, the lava flow in places provides a much more favorable environment for vegetation than the surrounding area receiving the same amount of precipitation. Particularly the crevices of the northern extension of the lava support a greater variety and a more mesic type of vegetation than the adjacent non-lava plain. Soil moisture seems to be the main factor in determining the distribution of three tree species, *Celtis reticulata, Juglans major,* and *Juni-*

perus monosperma, which occur within the lava but not in the immediately surrounding area. The greater number of plant species on the half of the lava flow definitely within the Upper Sonoran Zone is associated with the increase of three inches in precipitation between the southern and northern extremes of the lava. In addition to greater surface aridity, the more shallow southern part of the lava bed lacks the deeper, sheltered crevices characteristic of the northern half nearer the crater. *Yucca elata* grows up to the margin of the lava, but not within it, possibly because this species requires excess soil lime and because the poorly branched main roots tend to run laterally for five to ten feet. The survival of cacti within the malpais is favored by the few deep branches, in addition to the extensive, shallow root system, which penetrate the crevices, permitting absorption from several levels.

There are no plant indicators of lava as there are of gypsum. The vegetation of the lava flow is no different from that of other rocky habitats in the area except insofar as these environments are usually disturbed by the human factor, though overgrazing of the surrounding area may have influenced species available for seeding in, and traffic has introduced roadside species along the three crossings. The ruggedness of the lava serves to prevent invasion, particularly by livestock.

Summary

The localized distribution of plant species was noted for the northern half of the Tularosa Basin, which covers an area about 150 miles long and 40 miles wide in south central New Mexico. Upon this part of the basin floor two contrasting smaller environments are superimposed. One, a deposit of 97 percent gypsum 8 to 10 miles wide, extends northward from near the center of the basin for approximately 28 miles. The other, a recent lava flow ½ to 5 miles wide, was erupted around 59 miles to the north and flowed southward for 44 miles to within 15 miles of the gypsum deposit. Sixty-two plant species were collected from the gypsum sand and 134 species from the lava flow. Only 23 species are common to these two areas. From the alkaline plain adjacent on either side a total of 64 species was collected surrounding the White Sands and 61 species, exclusive of certain grasses, surrounding the lava flow. These two lists also have only 23 species in common. Twenty-six species are common to the White Sands and the surrounding plain, and 28 species, other than grasses, are common to the lava flow and the immediately surrounding basin floor.

A great variety of vegetation grows in the moist canyons of the mountains on either side of the basin. Salinity and aridity are the

factors which combine to eliminate all but xeric, salt tolerant species from the lowest parts of the basin floor. Concentric bands of saltbush, mesquite and creosote bush to the east and west of the White Sands reflect the diminishing gradient of alkaline salts going outward from the low central part of the basin. Dune movement and the concentrated calcium sulfate soil solution within the gypsum deposit eliminate 38 species found in the surrounding plain. Conversely, the shallow water table of the flats, where water stands within 3 feet of the surface, favors other species which do not survive in the surrounding area. Five gypsum indicators, favored by the concentrated calcium sulfate, grow within but not immediately surrounding the gypsum sand. Within the lava flow the diversity and abundance of vegetation in the shallow soil pockets in protected crevices and sinkholes increase with precipitation from a total, other than 20 grasses, of 28 species in the southern third of the flow, which is definitely within the Lower Sonoran Zone, to 99 species in the northern half entirely within the Upper Sonoran Zone. Each of these figures includes 14 species common to both zones.

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List I. PLANT SPECIES OCCURRING WITHIN THE CARRIZOZO LAVA FLOW AND THE ALAMOGORDO GYPSUM DEPOSIT AND THE SPECIES COMMON TO EITHER OF THESE AREAS AND THE SURROUNDING PLAIN. —The list below presents (a) in *italics*, the 111 species growing in the lava flow but not in the White Sands gypsum deposit; (b) in lower case, the 39 species found in the White Sands but not in the lava bed; and (c) in CAPITALS, the 23 species characteristic of both these environments. An asterisk indicates that a species also grows in the surrounding country within a ten-mile radius of the smaller area where it occurs naturally, either the lava flow, the White Sands or both. None of the lava grasses are starred because their distribution in the surrounding area has not been completely determined.

PTERIDOPHYTA

1.. POLYPODIACEAE
Cheilanthes feei Moore
Notholaena standleyi Maxon
Pellaea longimucronata Hook.

SPERMATOPHYTA—GYMNOSPERMAE

1. PINACEAE
Juniperus monosperma (Englem.) Sarg.
2. GNETACEAE
*EPHEDRA TORREYANA S. Wats.
E. viridis Coville

SPERMATOPHYTA—ANGIOSPERMAE
MONOCOTYLEDONEAE

1. GRAMINEAE
Andropogon saccharoides Swartz
A. SCOPARIUS Michx.
*Aristida adscensionis L.
A. longiseta Steud.
Bouteloua barbata Lag.
B. breviseta Vasey
B. curtipendula (Michx.) Torr.
B. eriopoda Torr.
B. gracilis (H.B.K.) Lag.
Bromus porteri (Coult.) Nash
*Distichlis spicata (L.) Greene (also surrounding lava)
Eragrostis pilosa (L.) Beauv.
Hilaria jamesii (Torr.) A. Gray
Muhlenbergia porteri Scribn.
*M. PUNGENS Thurb.
Munroa squarrosa (Nutt.) Torr.
*ORYZOPSIS HYMENOIDES (Roem. & Schult.) Ricker
Panicum obtusum H.B.K.
P. virgatum L.
Setaria macrostachya H.B.K.
Sitanion hystrix (Nutt.) J. G. Smith
*SPOROBOLUS AIROIDES Torr.
S. CRYPTANDRUS (Torr.) A. Gray
S. giganteus Nash
S. flexuosus (Thurb.) Rydb.
Trichachne californica (Benth.) Chase

2. JUNCACEAE
   Juncus mexicanus Willd.
3. LILIACEAE
   Dasylirion wheeleri S. Wats.
   Nolina microcarpa S. Wats.
   Yucca baccata Torr.
   Y. elata Engelm. (also surrounding lava flow)

DICOTYLEDONEAE

1. SALICACEAE
   POPULUS WISLIZENI (S. Wats.) Sarg.
2. JUGLANDACEAE
   Juglans major (Torr.) Heller
3. ULMACEAE
   Celtis reticulata Torr.
4. MORACEAE
   Morus microphylla Buckl.
5. LORANTHACEAE
   Phoradendron bolleanum (Seem.) Eichl.
6. SANTALACEAE
   Comandra pallida A. DC.
7. POLYGONACEAE
   Eriogonum abertianum Torr.
   E. tenellum Torr.
   E. wrightii Torr.
   **Rumex mexicanus* Meisn.
8. CHENOPODIACEAE
   *ALLENROLFEA OCCIDENTALIS (S. Wats.) Kuntze
   *ATRIPLEX CANESCENS (Pursh) Nutt.
   Chenopodium fremontii S. Wats.
   Chenopodium sp.
   Chenopodium sp.
   Eurotia lanata (Pursh) Moq.
9. AMARANTHACEAE
   Amaranthus albus L.
   TIDESTROMIA LANUGINOSA (Nutt.) Standl. (also surrounding White Sands)
10. NYCTAGINACEAE
   Allionia choisyi Standl.
   Abronia angustifolia Greene
   Boerhaavia caribaea Jacq.
   B. gypsophiloides Coult.
   **Mirabilis multiflora* (Torr.) A. Gray
   M. oxybaphoides A. Gray
   Oxybaphus linearis (Pursh) Robinson
   Selinocarpus chenopodioides A. Gray
11. PORTULACACEAE
   Portulaca umbraticola H. B. K.
   P. parvula A. Gray
12. RANUNCULACEAE
   Clematis neomexicana Woot. & Sandl.
13. BERBERIDACEAE
   Berberis haematocarpa Wooton
14. CRUCIFERAE
   Descurainia pinnata halictorum (Cockerell) Detling
   Dithyrea wislizeni Engelm.
   **Nerisyrenia camporum* (A. Gray) Greene
   N. linearifolia (S. Wats.) Greene
   Lepidium alyssoides A. Gray (also surrounding lava and along roadsides within lava bed)
   Sisymbrium linifolium Nutt.
   Thelypodium wrightii Gray

15. CAPPARIDACEAE
Polanisia uniglandulosa (Cav.) DC.
16. ROSACEAE
Cercocarpus breviflorus A. Gray
Fallugia paradoxa (D. Don) Endl.
17. LEGUMINOSAE
Astragalus tephrodes A. Gray
Cassia roemeriana Scheele
Dalea formosa Torr.
D. scoparia A. Gray
**Hoffmanseggia densiflora* Benth. (also surrounding White Sands)
H. jamesii Torr. & Gray
**Prosopis juliflora* (Swartz) D. C. var. *glandulosa* (Torr.) Cockerell (occasional surrounding White Sands)
Schrankia occidentalis (Woot. & Standl.) Standl.
18. ZYGOPHYLLACEAE
**Larrea tridentata* (DC) Coville
19. EUPHORBIACEAE
Tragia nepetaefolia Cav.
20. ANACARDIACEAE
**Rhus microphylla* Englm.
R. TRILOBATA Nutt.
21. MALVACEAE
Abutilon incanum (Link) Sweet
*SPHAERALCEA ANGUSTIFOLIA (Cav.) G. Don
S. fendleri A. Gray
*S. INCANA Torr.
S. rotundifolia (Gray) Jepson
22. TAMARICACEAE
*TAMARIX GALLICA L.
23. FRANKENIACEAE
*FRANKENIA JAMESII Torr.
24. LOASACEAE
MENTZELIA INTEGRA (M. E. Jones) Tidestrom (also surrounding White Sands)
M. pumila (Nutt.) Torr. & Gray
25. CACTACEAE
Echinocereus gonacanthus (Engelm. & Bigel.) Lem.
**Opuntia engelmannii* Salm-Dyck (also surrounding White Sands)
**O. imbricata* Engelm.
O. leptocaulis DC.
O. phaecantha DC.
Opuntia sp.
26. ONAGRACEAE
**Gaura coccinea* Nutt.
Oenothera hartwegii Benth. var. filifolia (Eastw.) Munz
O. hartwegii Benth. var. typica Munz
O. runcinata var. gypsophila (Eastw.) Munz
27. CORNACEAE
Garrya wrightii Torr.
28. PLUMBAGINACEAE
Limonium californicum (Boiss.) Heller
29. GENTIANACEAE
Centaurium texense (Griseb.) Fernald
Eustoma exaltatum (L.) Griseb. (also marginal to lava at Malpais Springs)
30. ASCLEPIADACEAE
Asclepias arenaria Torr.
31. CONVOLVULACEAE
Cuscuta umbellata H. B. K.
Ipomoea coccinea var. *hederifolia* (L.) Gray

32. POLEMONIACEAE
Gilia longiflora (Torr.) Don (also along roadsides within lava)
Phlox stansburyi (Torr.) Heller
33. HYDROPHYLLACEAE
Nama carnosum (Wooton) C. L. Hitchc.
Phacelia crenulata Torr.
P. corrugata A. Nels.
34. BORAGINACEAE
Coldenia hispidissima (Torr.) A. Gray
Cryptanthe crassisepala (Torr. & Gray) Greene
C. thyrsiflora (Greene) Payson
Lappula texana (Scheele) Britton
35. VERBENACEAE
Lippia wrightii A. Gray
Verbena bipinnatifida Nutt.
V. wrightii A. Gray
36. LABIATAE
Hedeoma nanum (Torr.) Greene
Marrubium vulgare L.
Poliomintha incana (Torr.) A. Gray
Salvia henryi Gray
S. vinacea Woot. & Standl.
37. SOLANACEAE
*LYCIUM BERLANDIERI Dunal var. PARVIFLORUM (Gray) Terrac.
L. pallidum Miers (also surrounding White Sands)
*L. TORREYI A. Gray
Physalis neomexicana Rydb.
*Solanum elaeagnifolium Cav. (also surrounding lava flow and along roadsides within lava)
38. SCROPHULARIACEAE
Antirrhinum maurandioides (Willd.) Hitchc.
Castilleja integra A. Gray
39. CUCURBITACEAE
*CUCURBITA FOETIDISSIMA H. B. K.
40. COMPOSITAE
Artemisia bigelovii A. Gray
A. dracunculus L. var. *glauca* (Pallas) Harv. & Gray
A. filifolia Torr.
A. ludoviciana Nutt.
**A. tridentata* Nutt.
*Baccharis glutinosa Pers.
B. ramulosa A. Gray
Bahia pedata A. Gray
Brickellia californica (Torr. & Gray) Gray
Chrysopsis hispida (Hook.) DC.
C. villosa (Pursh) Nutt.
Chrysothamnus nauseosus (Pall.) Britton
C. pulchellus (A. Gray) Greene
Clappia suaedifolia A. Gray (also marginal to lava at Malpais Spring)
Gutierrezia lucida Greene
*G. SAROTHRAE (Pursh) Britt. & Rusby
*Haplopappus heterophyllus (A. Gray) Blake (also marginal to lava at Malpais Spring)
H. SPINULOSUS (Pursh) DC.
*Helianthus annuus L. (also surrounding lava flow and along roadsides within lava)
Hymenopappus arenosus Heller
Kuhnia chlorolepis Woot. & Standl.
Machaeranthera cichoriacea Greene
M. linearis Greene (also along roadsides in lava)

Melampodium leucanthum Torr. & Gray
Pectis papposa Harv. & Gray
*PSILOSTROPHE TAGETINA (Nutt.) Greene
**Senecio longilobus* Benth.
S. quaerens Greene
S. spartioides Torr. & Gray
Stephanomeria pauciflora (Torr.) A. Nels.
Thelesperma megapotamicum (Spreng.) Kuntze
*VERBESINA ENCELIOIDES (Cav.) Benth. & Hook.
*Zinnia grandiflora Nutt. (also surrounding lava flow and along roadsides within lava)

List II. THE 38 SPECIES IN THE SURROUNDING AREA WITHIN A TEN-MILE RADIUS OF THE WHITE SANDS GYPSUM BED, BUT NOT IN ANY PART OF THE GYPSUM DEPOSIT.

* Also in the area surrounding the lava flow, but not in lava proper.
** Also along roadsides within the lava, but not in lava proper.

1. GNETACEAE
   Ephedra trifurca Torr.
2. TYPHACEAE
   Typha angustifolia L.
   **T. latifolia* L.
3. GRAMINEAE
   Sporobolus nealleyi Vasey
4. CYPERACEAE
   Scirpus paludosus A. Nels.
5. SALICACEAE
   Salix nigra Marsh.
6. POLYGONACEAE
   Eriogonum rotundifolium Benth.
7. CHENOPODIACEAE
   ***Salsola kali* var. *tenuifolia* Tausch (also marginal to lava)
   Suaeda suffrutescens S. Wats.
   S. torreyana S. Wats.
8. AMARANTHACEAE
   Amaranthus retroflexus L.
9. KOEBERLINIACEAE
   **Koerberlinia spinosa* Zucc.
10. CRUCIFERAE
    Streptanthus arizonicus S. Wats.
11. LEGUMINOSAE
    Prosopis juliflora (Swartz) DC. var. *glandulosa* (Torr.) Cockerell
    Cassia lindheimeriana Scheele
    Hoffmanseggia densiflora Benth.
12. MALVACEAE
    ***Sida lepidota* A. Gray
13. EUPHORBIACEAE
    Euphorbia albomarginata Torr. & Gray
14. RHAMNACEAE
    Condalia spathulata A. Gray
15. CACTACEAE
    Opuntia engelmannii Salm-Dyck
16. ONAGRACEAE
    Gaura coccinea Nutt.
17. APOCYNACEAE
    Amsonia arenaria Standley
18. PLUMBAGINACEAE
    Limonium limbatum Small
19. ASCLEPIADACEAE
    ***Asclepias galioides* H.B.K.

20. CONVOLVULACEAE
    Cressa truxillensis H.B.K.
    Ipomoea hirsutula Jacq.
21. BORAGINACEAE
    Heliotropum greggii Torr.
    Cryptanthe fulvocanescens (Gray) Payson
22. VERBENACEAE
    Verbena bracteata Lag. & Rodr.
23. SOLANACEAE
    Lycium pallidum Miers
24. BIGNONIACEAE
    Chilopsis linearis (Cav.) Sweet
25. COMPOSITAE
    Cirsium wheeleri (A. Gray) Petrak
    Dicranocarpus parviflorus A. Gray
    Erigeron arenarius Greene
    Flourensia cernua DC.
    Hymenoclea monogyra Torr. & Gray
    Machaeranthera parviflora A. Gray
    *Perezia nana A. Gray

List III. THE 29 PLANT SPECIES IN THE SURROUNDING AREA WITHIN A TEN-MILE RADIUS OF THE LAVA, BUT NOT WITHIN THE LAVA DEPOSIT.

(Four additional species, designated by an asterisk in List II, are not repeated here.)

* Also along roadsides within the lava flow.

1. GRAMINEAE
    **Cenchrus pauciflorus* Benth.
    Distichlis spicata (L.) Greene
    Phragmites communis Trin.
    **Sorghum halepense* (L.) Pers.
2. CYPERACEAE
    Scirpus americanus Pers.
3. LILIACEAE
    Yucca elata Engelm.
4. FOUQUIERIACEAE
    Fouquieria splendens Engelm.
5. CARYOPHYLLACEAE
    Arenaria capillaris Poir.
6. CRUCIFERAE
    **Lepidium alyssoides* A. Gray
7. MALVACEAE
    **Sphaeralcea subhastata* Coult.
8. CACTACEAE
    Opuntia clavata Engelm.
9. GENTIANACEAE
    Eustoma exaltatum (L.) Griseb.
10. SOLANACEAE
    **Chamaesaracha conioides* (Moric.) Britton
    **C. coronopus* (Dunal) A. Gray
    Datura stramonium L.
    **Solanum elaeagnifolium* Cav.
11. SCROPHULARIACEAE
    Penstemon ambiguus Torr. X *P. thurberi* Torr.
12. COMPOSITAE
    Bahia absinthifolia Benth.
    Baileya multiradiata Harv. & Gray

**Cirsium ochrocentrum* A. Gray
Clappia suaedifolia A. Gray
**Grindelia aphanactis* Rydb.
Haplopappus heterophyllus (A. Gray) Blake
**Helianthus annuus* L.
H. ciliaris DC.
Hymenoxys odorata DC.
Parthenium incanum H.B.K.
Verbesina rothrockii Robins. & Greenm.
Zinnia grandiflora Nutt.

List IV. THE 10 SPECIES GROWING ALONG ROADSIDES WITHIN AND OUTSIDE THE LAVA, BUT NOT IN THE LAVA PROPER NOR ON THE SURROUNDING RANGE LAND.

1. CHENOPODIACEAE
   Salsola kali var. *tenuifolia* Tausch
2. MALVACEAE
   Sida lepidota A. Gray
   Sphaeralcea coccinea (Pursh) Rydb.
3. ASCLEPIADACEAE
   Asclepias brachystephana Engelm.
   A. asperula (Decaisne) Woodson
4. COMPOSITAE
   Erigeron canadensis L.
   E. divergens Torr. & Gray
   Helianthus anomalus Blake
   Iva dealbata A. Gray
   Machaeranthera linearis Greene

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DIONDA DIABOLI (CYPRINIDAE), A NEW MINNOW FROM TEXAS

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ABSTRACT. A new minnow, *Dionda diaboli*, related to *D. episcopa* Girard and *D. rasconis* (Jordan and Snyder), is decribed. The new species is based on specimens from the Devil's River and other spring-fed tributaries to the Rio Grande in Kinney and Val Verde counties, Texas. The holotype is University of Michigan Museum of Zoology No. 168971. Several populations of both related species were studied. The species are found to be made up of many isolated and morphologically distinct populations.

Dionda diaboli, new species

DIAGNOSIS. Lateral line scales 32 to 36; head small and narrow; intestine long and coiled; caudal spot wedge shaped; scale pockets on dorsum pronounced.

DESCRIPTION. Fin and scale formulae: dorsal 8 (rarely 9); anal 8 (rarely 6 to 11); caudal 19 (rarely 18); pelvic 8 (rarely 6 or 7); pectoral 14 or 15 (rarely 13 or 16); lateral line 33 to 35 (rarely 32 or 36).

Head small and narrow. Subinferior mouth reaches to a point below anterior nostril. Eye slightly longer than snout. Greatest body depth in front of pelvic fins. Caudal peduncle narrow. Fins short and rounded. Dorsal origin slightly posterior to pelvic origin. Intestine long and coiled. Peritoneum black.

Breeding males have tubercles evenly distributed over top of head and on pectoral fin rays.

Pharyngeal teeth 0-4-4-0. Each tooth long and narrow. Upper and lower teeth approximately as long as pharyngeal arch beyond respective tooth base.

Color pattern distinctive. Pronounced lateral stripe, that extends through eye onto snout, not reaching lower lip. Lateral stripe separated from a caudal spot by distance almost equal to length of caudal spot. Spot wedge-shaped, much deeper than long and about one-third of body depth at base of caudal. Scale pockets above lateral stripe have prominent dark markings giving back cross-hatched appearance. These markings may extend below lateral stripe in front of dorsal and

behind anal. Superimposed on these markings are doubled dashes along lateral line similar to those of *Notropis deliciosus*. They are less noticeable in *D. diaboli* as they are obscured by more prominent color markings. Middorsal stripe connects dorsal scale pocket markings. Middorsal stripe darkest along base of dorsal fin.

RANGE. At the present time *D. diaboli* is known only from the headwaters of the Devil's River, San Felipe Creek, and Las Moras Creek. As the first collections containing this species were made after 1950 we have no information on possible historic changes in its geographic distribution. However, we do not suspect any such change in historic time. Minor morphologic differences between the three isolated populations indicate genetic differences that would probably require years to develop. Very little negative information is available as the first collections made within the *D. diaboli* range in either the Devil's River or Las Moras Creek contained *D. diaboli*. Seven collections had been made in San Felipe Creek prior to Suttkus' 1955 collection. We suspect that the previous collectors missed the species and Suttkus obtained it either by chance or by superior technique.

Each collection from the Devil's River that contained specimens of *D. diaboli* also contained many *D. episcopa*. Many seine hauls have contained both species. Within the Devil's River, *D. diaboli* is restricted to the headwaters and is more common than *D. episcopa* only at Baker's Crossing where the water is murky.

No *D. episcopa* have been reported from Las Moras Creek.

HOLOTYPE. Female. University of Michign Museum of Zoology No. 168971. Collected from the Devil's River at Baker's Crossing (Lat. 29° 57' N., Long. 101° 09' W.), 18 May 1954, by Brown and party.

PARATYPES. Three, UMMZ No. 168972, collected with holotype—Fifty-four, Texas Natural History Collection No. 4214, same locality and collectors, 29 July 1953.—Nine, U.S. National Museum No. 164251, from Pecan Springs (Lat. 30° 03' N., Long. 101° 11' W.), 7 October 1953, Brown and party.—Thirty-six, UMMZ No. 168973, Devil's River 2 miles south of Pecan Springs, 9 September 1953, Brown and party.—One, TNHC No. 3412, Devil's River just north of Dolan Falls (Lat. 29° 53' N., Long. 101° 00' W.), 29 May 1953, Clark Hubbs and Kirk Strawn.—One, springs at head of Devil's Lake (Lat. 29° 39' N., Long. 100° 59' W.), 22 July 1953, Brown and party.—Two, Chicago Natural History Museum No. 61606, same locality and collectors, 27 March 1954.—One, TNHC No. 4234, springs in Devil's Lake (Lat. 29° 36' N., 100° 57' W.), 17 February 1955, Elgin M. C. Dietz.

OTHER SPECIMENS. Five, Tulane University No. 10413, San Felipe Creek at Del Rio, 22 June 1955, by R. D. and J. S. Suttkus.—Thirty-nine, TNHC No. 1852, Las Moras Creek at Bracketville, 14 April 1951, by

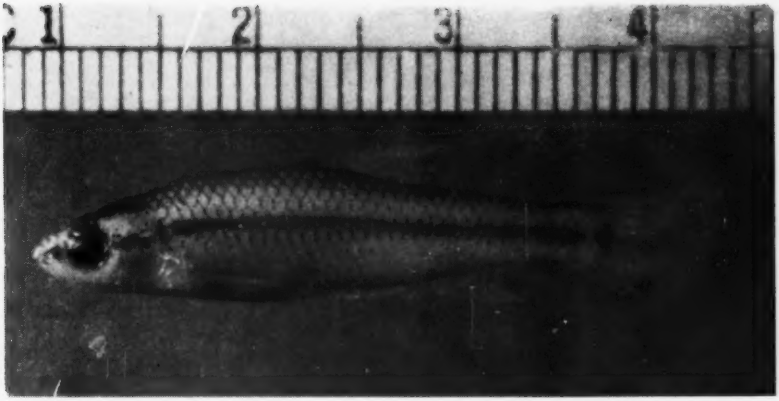

Fig. 1. *Dionda diaboli* (29 mm. specimen) from San Felipe Creek.

Thomas E. Kennerly, Jr., Jack Herrmann, and Floyd Potter.—One, same locality, May 1955, Wayne E. Dear.

Although Girard described many nominal species now considered to be synonyms of *Dionda episcopa* from the Rio Grande drainage, none of the descriptions mentioned the pronounced color pattern or the low lateral line scale counts by which *D. diaboli* can easily be distinguished from *D. episcopa*. The types of one nominal species, *D. argentosa* Girard (1856), are from the Devil's River and San Felipe Creek, localities in which this species is known to live. Girard's description of the fish is so general that it may fit almost any cyprinid. The color pattern description (reddish brown back and silver abdomen), however, does fit *D. episcopa* far better than *D. diaboli*, which has more pronounced color markings and a gray dorsum. Girard (1858) contained a "size of life" figure of *D. argentosa*. This figure is 64 mm. standard length. Our largest *D. diaboli* specimens are 53 mm. standard length and many *D. episcopa* collections contain specimens up to 64 mm. standard length. This figure also has about 41 lateral scales. Our specimens of *D. diaboli* have 32 to 36 lateral line scales, and *D. episcopa* from the Devil's River and San Felipe Creek have 36 to 41 lateral line scales. The figured specimen, therefore, must be *D. episcopa*. Evermann (1893) apparently examined the type (USNM No. 32) and reported it to be stouter than typical *D. episcopa*. As *D. diaboli* is slimmer than *D. episcopa*, the type could not be this species.

Comparison with Dionda rasconis

We have compared our specimens of *D. diaboli* with ten specimens of *D. rasconis* (Jordan and Snyder, 1901) from Rascon, San Luis Potosí,

Characteristic	D. rasconis Rascon	D. diaboli Devil's River	D. diaboli Las Moras Creek	D. episcopa Nueces system	D. episcopa Devil's River
Snout to Occiput[1]	239(224-254)	213(203-226)	208(198-218)	237(222-246)	238(225-245)
Orbital L.[1]	91 (87-96)	80(73-84)	76(69-83)	80(78-84)	87(80-95)
Depressed Dorsal[2]	259 (247-286)	222(211-245)	228(219-244)	227(213-243)	215(195-233)
Depressed Anal[2]	212 (204-229)	187(177-196)	194(183-206)	191(183-206)	176(159-186)
Caudal Peduncle Length	240(227-251)	221(206-237)	225(207-247)	225(192-242)	219(199-233)
Caudal Peduncle Depth	109(103-113)	98(84-105)	106(94-120)	112(103-122)	110(100-119)
Pelvic Length[2]	177(167-187)	153(147-176)	159(151-175)	158(142-167)	145(134-157)
Pectoral Length[2]	196(188-211)	178(163-209)	176(166-190)	188(164-211)	192(166-214)
Snout to Pectoral	511(495-524)	488(471-517)	483(473-510)	498(474-514)	506(491-517)
Body Depth	257(220-279)	237(209-260)	248(225-263)	250(222-277)	243(220-255)
Postorbital Length	109(100-118)	95(88-104)	96(88-102)	106(98-114)	103(95-109)

Fig. 2. Comparison of 37 to 47 mm. standard length specimens from fivepopulations of *Dionda*.

Mexico, as well as the descriptions of that species in Jordan and Snyder, Meek (1904), and Alvarez and Navarro (1953) who described a southern race as *Notropis ipni*. Meek considered that *D. rasconis* was closely related to *D. episcopa* and placed both species in the genus *Hybognathus*. We feel that the genera *Dionda* and *Hybognathus* represent different phyletic lines of descent from the genus *Notropis* and thus are both valid. We consider that Jordan and Snyder's species should be placed in *Dionda*.

Dionda rasconis is the only species now included in the genus *Dionda* which has meristic characters that do not differ markedly from those of *D. diaboli*. Counts for southern specimens (nominal species *D. ipni*) however, are higher than those for the northern ones (typical *rasconis*) or *D. diaboli*, often with little or no overlap.

The color pattern of *D. diaboli* superficially resembles that of *D. rasconis*, but on close examination the two are easily separated. The caudal spot of the later is pronounced, but is not separated from the lateral band as is that of *D. diaboli*. The caudal spot of *D. diaboli rasconis* is rounded and its depth is about one-fifth of the caudal peduncle depth. The scale pocket markings are not pronounced in *D. rasconis*. We can find no trace of any doubled dashes along the lateral line of *D. rasconis*.

There are a number of proportional measurements by which *D. diaboli* can be distinguished from *D. rasconis* (Fig. 2). In each of the proportions used, the figures for *D. rasconis* are greater than those for *D. diaboli*. There is no overlap in the figures for the orbital length or depressed dorsal length, and very little overlap in the snout to occiput length, depressed anal length, or postorbital length

Comparison with D. episcopa

We have also compared our specimens of *D. diaboli* with specimens from many populations now considered to belong to *D. episcopa* Girard (1856). This latter species is made up of a large number of isolated populations, many of which can be considered as separate subspecies following the criteria given by Carl L. Hubbs and Clark Hubbs (1953). We suspect that each isolated population could be shown to be "subspecifically distinct" by intensive study. Often a population differs markedly from those adjacent to it, *i.e.*, a population from an unnamed creek 12 miles southwest of Camargo, Chihuahua, Mexico, has fewer lateral line scales than those populations from other parts of the Rio Conchos drainage (Fig. 3). This same population differs from the others from the Rio Conchos system by usually having eight instead of seven anal rays. Some populations from remote localities are morphologically similar, *i.e.*, the populations from those tributaries of the Guadalupe and Colorado rivers flowing through the Edwards Plateau,

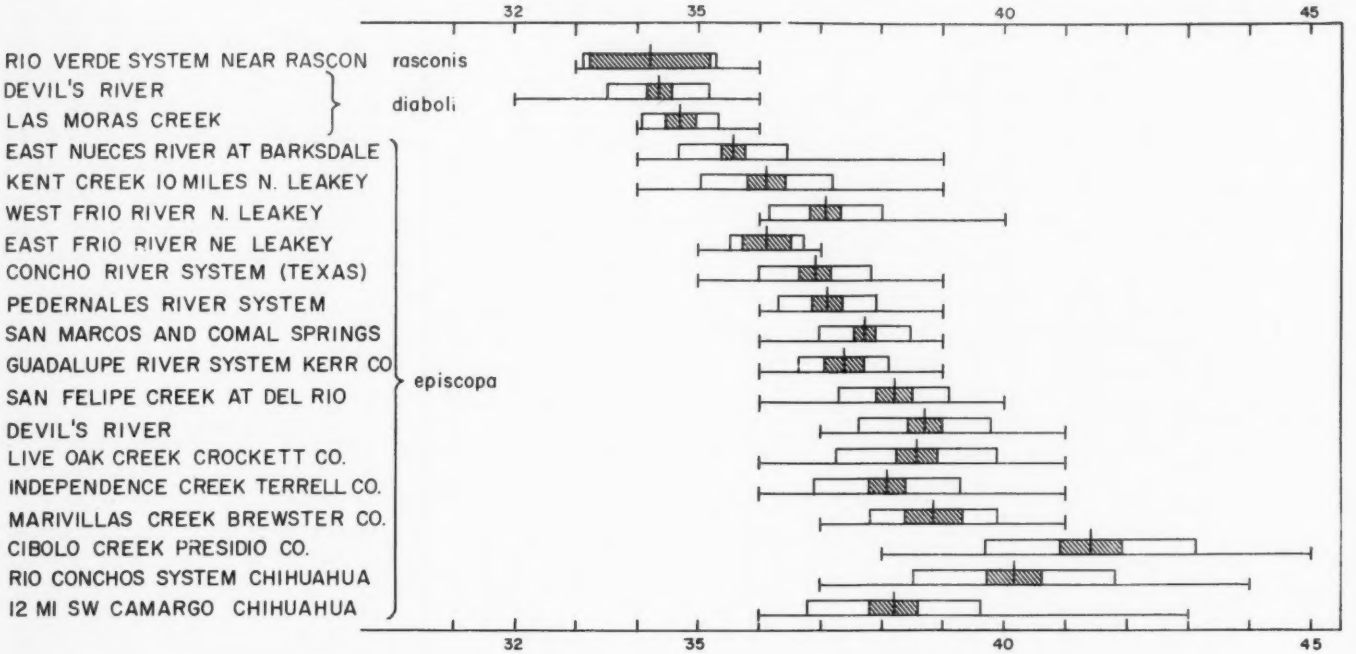

Fig. 3. Number of lateral line scales in several samples of *Dionda*.

are morphologically similar to those inhabiting the Rio Sabinas de Coahuila. Moreover, populations from Comal and San Marcos springs are quite distinct from those of other tributaries to the Guadalupe River (Clark Hubbs, Kuehne, and Ball, 1953). We do not deem it advisable either to resurrect old names or to propose new names for these populations, but prefer to designate them by their geographic localities. As each morphologic type is geographically isolated from all other morphologic types, we do not concur with Knapp (1953), who suspected that two subspecies of *Dionda episcopa* are separated ecologically. All of the *Dionda episcopa* populations that we have studied intensively are restricted to clear, spring-fed waters, which have little temperature variation. Likewise we do not concur with Knapp's inclusion of the Guadalupe River within the range of the nominal subspecies *D. episcopa serena*. The populations comprising this nominal subspecies are easily distinguished from all others of *D. episcopa* and are restricted to the headwaters of the Nueces River system. In many characters the Nueces River populations of *D. episcopa* approach the morphologic characteristics of *D. diaboli*.

The color pattern of *D. diaboli* is very distinct from that of all populations of *D. episcopa* except from the headwaters of the Nueces River. The dorsal scale pocket markings are virtually absent in all but the Nueces River populations and weak in the latter. The doubled dashes along the lateral line are present only in the Nueces River populations. However, the caudal spot is rounded in all populations of *D. episcopa* and about one-fifth of the caudal peduncle depth. This spot is weakest in the Nueces River populations.

Dionda diaboli differs from *D. episcopa* in having a shorter distance between the snout and occiput, narrower caudal peduncle, shorter pectoral fin, shorter pectoral length, and shorter postorbital head length (Fig. 2). In two of the above, caudal peduncle depth and postorbital length, the Devil's River sample of *D. episcopa* approaches *D. diaboli* more than does the Nueces River sample. In four proportional measurements, orbital length, depressed dorsal length, depressed anal length, and pelvic length, the Devil's River sample of *D. episcopa* differs from both *D. diaboli* and the Nueces River sample of *D. episcopa*. Nueces River populations of *D. episcopa* almost always have seven anal rays, while those of *D. diaboli* and most other Texas populations of *D. episcopa* seldom if ever have fewer than eight anal rays. The populations of *D. episcopa* from the Devil's River have more than one-half of the individuals with eight anal rays. *Dionda diaboli* usually has fewer lateral line scales than any of the *D. episcopa* populations studied (Fig. 3). In this character, the Nueces River populations of *D. episcopa* approach *D. diaboli*.

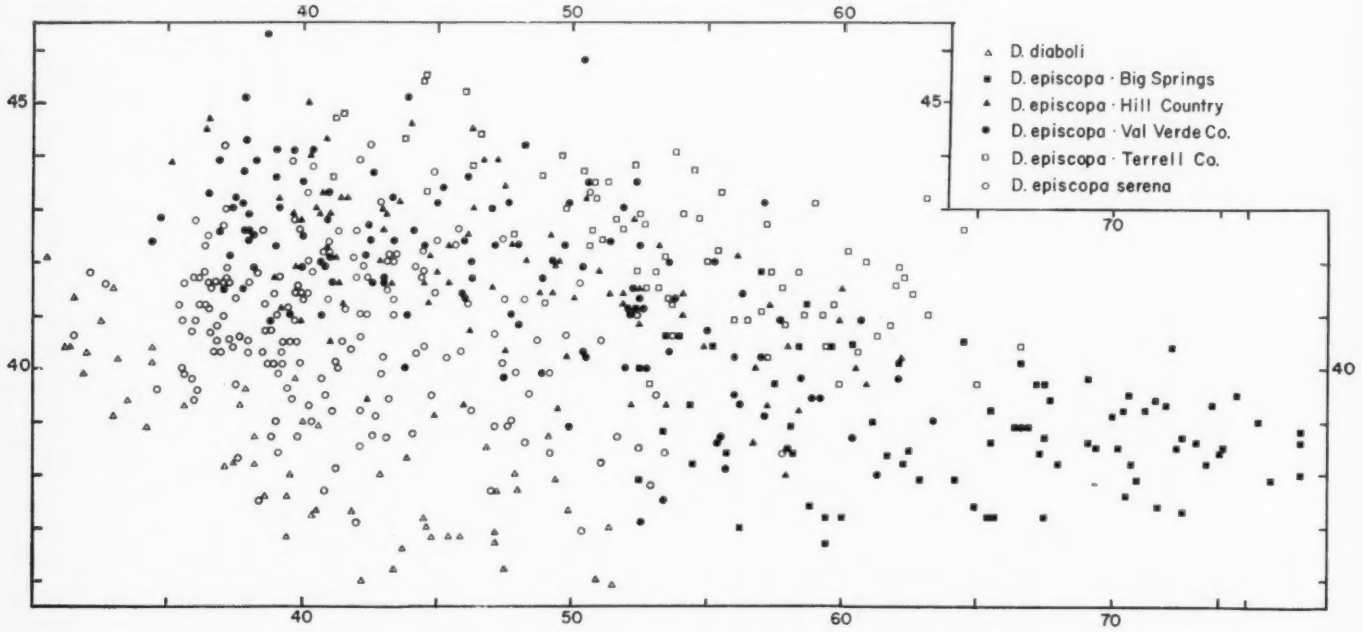

Fig. 4. Snout-to-occiput length added to distance between occiput and isthmus divided by standard length in percents for six samples of *Dionda*.

We have also compared the proportion of the distance from the snout to the occiput to the isthmus among five populations of *D. episcopa* with that proportion in *D. diaboli* (Fig. 4). Although three of the *D. episcopa* samples appear very similar in this character, they are plotted separately because they are readily distinguished by color variations. Using this character index *D. diaboli* has little or no overlap with any populations of *D. episcopa* except from the headwaters of the Nueces River system. Moreover, the allometric growth rate of *D. diaboli* is greater, and the point of inflection is at a smaller size.

Although the Nueces River populations of *D. episcopa* are intermediate between the other populations of *D. episcopa* and those of *D. diaboli* in some characteristics, the Nueces River populations are extreme in others. We do not suggest that there has been any interbreeding between *D. diaboli* and typical *D. episcopa* to produce the Nueces River populations of *D. episcopa*.

Methods and Acknowledgements

The techniques used for measurements and counts are those given by Carl L. Hubbs and Lagler (1947). The method for graphical analysis is that proposed by Carl L. Hubbs and Clark Hubbs (1953).

The collections made by Brown have been made as a part of Dingle-Johnson Federal Aid Project F-9-R, Job B-6. The collection made by Hubbs and Strawn was made during a field trip supported by the National Science Foundation.

We wish to thank the various individuals cited above for their assistance in collecting specimens, and all of the unlisted persons who helped collect the comparative series of *D. episcopa*. We also wish to thank numerous landowners for permission to collect on their property. Mr. Loren P. Woods of the Chicago Natural History Museum kindly loaned us specimens of *Dionda rasconis* for purposes of comparison. Dr. Carl L. Hubbs has advised us during the investigation. The conclusions, however, are our own. Miss Nancy Jo Walker prepared Fig. 2. Mrs. Grace Hewitt Groce prepared Figs. 3 and 4. The photograph (Fig. 1) was made by Fred G. Lowman, Jr.

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THE SOUTHWEST NATURALIST 1 (2): 78—82 APRIL, 1956

RANGE AND NATURAL HISTORY OF THE RINGED SALAMANDER, AMBYSTOMA ANNULATUM COPE (AMBYSTOMIDAE)

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ABSTRACT. Information on the known range and breeding habits of *Ambystoma annulatum* is summarized. The restriction of the range to the Interior Highland is pointed out, and 3 new breeding localities (Washington and Madison counties, Arkansas) are reported. Breeding occurs in fall, following rains; larval period is estimated to be between 215 and 225 days.

Ambystoma annulatum has always been considered a rare salamander. First described by Cope (1886: 525) from an unlabeled "specimen in a spirit bottle," it was not even known to be of North American provenience until Brimley collected the second known specimen near Hot Springs, Arkansas (Stejneger, 1894: 599) some eight years later. The following year B. L. Combs (as reported by Strecker, 1908: 85) collected another specimen at the same locality, but it was over thirty more years before the first range extension was reported (Noble and Marshall, 1929: 1). The new locality was in Stone County, Missouri, leaving a gap of more than 150 miles between the known points of occurrence. After another wait of over twenty years, three papers appeared in rapid succession extending the known range northward and eastward to Camden (Smith, 1950) and Gasconade (Anderson, 1950) counties, Missouri, and westward to Adair County, Oklahoma (Firscheim and Miller, 1951).

Members of the herpetology class at the University of Arkansas first discovered this salamander in Washington County in the spring of 1953, and several specimens have been found in other nearby localities since that time (Figure 1 and Collection List). The work here indicates that *A. annulatum* is actually a rather common salamander in the Interior Highland, and that its rarity in collections is due to the short and unusually-timed breeding season. Other than during the breeding season the species apparently spends little or no time above ground.

BREEDING ACTIVITIES

Casual observations have been made of the breeding activities of *Ambystoma annulatum* in Washington County, Arkansas, since it was first discovered there in 1953. A more intensive study was inaugurated

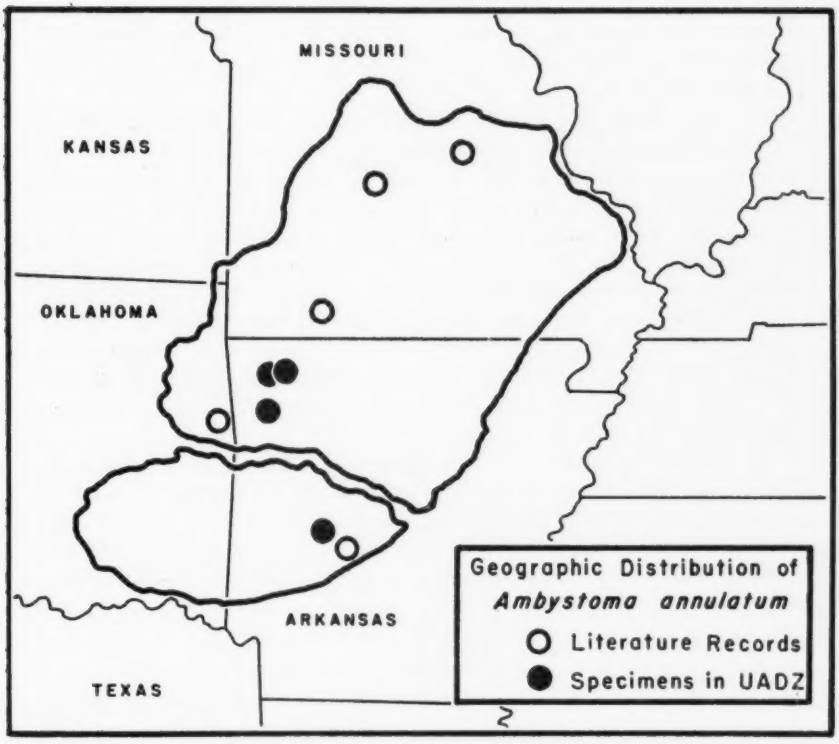

Fig. 1. Known distribution of *Ambystoma annulatum* in the interior Highland of North America. Outlined areas are the Ozark Plateau (to the north) and Ouachita Mountains. Localities represented by specimens in the University of Arkansas Department of Zoology collections (UADZ) have not been previously reported.

by the author in the fall of 1955 in an attempt to resolve the numerous discrepancies in the two previous reports of the breeding habits (Combs as reported by Strecker, 1909, in Garland County, Arkansas; Noble and Marshall, 1929, in Stone County, Missouri), and to add to the available information.

The main points of disagreement between these two papers have to do with the time of breeding and the breeding site. Combs found a salamander laying eggs in the spring, as do most species of *Ambystoma* (March, 1895), and laying them on land, under a log alongside a creek. Conversely, Noble and Marshall reported finding great masses of eggs after a slight rain in the fall. These were all in a pond, some attached to vegetation, but most scattered along the bottom. None were found

on land although this possibility was investigated. Another difference is that Combs reported the eggs were laid singly whereas Noble and Marshall found them to be mainly in masses, ranging from ten to forty-five eggs per mass.

The first local observation on this species was occasioned by a single adult individual being seined out of a pond along with two adults of *Ambystoma maculatum* and numerous egg masses on February 14, 1953. Unfortunately there is no information as to whether the egg masses were of *A. annulatum* or of *A. maculatum*, but more recent observations appear to favor the latter. This pond is a muddy, intermittent pool about 40 feet in length by 30 feet in width. Its greatest depth is about two feet when full (which is seldom the case), and it averages perhaps half that overall. It is located about eight miles northeast of Fayetteville, Washington County, and near a small church. It will be referred to hereafter as the Church Pond. This pond has been under observation since the above date.

The second observation on breeding habits was made by Robert S. Chase and Herndon G. Dowling on the night of October 4, 1953. A heavy (1.5 inch) rain had fallen, the first in months, and several crushed *A. annulatum* and two living individuals were found on the wet highway where it curved down a steep hillside about seven miles northeast of Fayetteville. The Church Pond, about a mile farther east, was also visited, and twelve specimens were taken at the edge of the pond. No eggs had been laid. The following year, again with the first heavy rain of the fall (2.9 inches on September 29), this species was found crossing the highway in the same place. Although no salamanders were found at the Church Pond that evening, *A. annulatum* eggs were discovered in a cattle pond near the hillside (Oxford Pond) in the first week of October.

Neither eggs nor larvae were found in either of these ponds in the spring of 1954 nor that of 1955. Presumably they had dried up during the winter. However, in the spring of 1955 a third breeding pond was discovered in Maidson County, about two miles north of Hindsville (Hindsville Pond). Unlike the others this is a more permanent pond with cattails growing in one end, located at the edge of an extensive woods. *Ambystoma annulatum* larvae averaging about 45 mm. in length were collected there on May 14. These larvae metamorphosed by the first of June. A recently transformed specimen was collected near the edge of the pond on June 10.

A closer check was kept on conditions during the fall of 1955. On September 26 the Church Pond and Hindsville Pond were visited and both were found to be dry. The mud making up the pond beds was dry and deeply cracked, indicating that no rain had fallen in many weeks.

During the first heavy rain (night of September 30), three adults were again found crossing the highway at the hillside. A fourth adult, a female with eggs, was found in the grass at the edge of the Church Pond but no other individual nor eggs were seen. The pond contained water at this time. On the night of October 3 a light rain fell and the Church Pond and Hindsville Pond were again visited. No adults were seen at either locality, but both ponds contained large numbers of egg masses which were attached to some form of vegetation, either floating or growing on the bottom. The masses in the Church Pond were large and heavily covered with silt, while at the Hindsville Pond the masses were smaller and covered with algae. Several of the egg masses were counted. In the Church Pond the number of eggs per mass ranged from 4 to 31, with a mean of 14.0 and a standard deviation of 6.18. In the Hindsville Pond the range was from 2 to 17, with a mean of 7.8 and a standard deviation of 4.68. Some of the masses in the Hindsville Pond had been disturbed by winds, which accounts for the differences found between the two points. These counts are similar to those of Noble and Marshall (1929: 5). Other masses were collected, some of which were preserved while others were placed in shallow bowls of water to hatch.

Nine days later, on October 12, the eggs in the laboratory began hatching. Observations were made at the Church Pond that same day and it was found that the egg masses there had also begun hatching. The water was extremely low and sections of some masses attached to the taller vegetation had dried out.

Two weeks later, on November 2 and 4, the Church and Hindsville ponds were again visited. Both were dry even though it had rained recently. On the latter date a fifth breeding site was discovered, in a pond in Washington County near the Madison County line, about two miles east of Mayfield. Since this pool contained water at the time, it is a more suitable site, and will be studied in the future.

Discussion

According to the observations made in Washington and Madison counties, *Ambystoma annulatum* lays its eggs at the time of the first heavy rains in the fall of the year. No eggs have been found in the ponds in spring although larvae just prior to transformation have been collected then. From the data obtained, a possible larval period may be determined. This period can be estimated as being between 215 and 225 days, assuming the eggs were laid about October 1 and transformation occurred around June 1.

The observations recorded here agree with those of Noble and Marshall in all but one respect. Noble and Marshall found the eggs to be mostly scattered on the bottom of the pond, while the findings here

indicate the masses are attached to some form of vegetation. The choice of the egg-laying site agrees with that reported by Noble and Marshall in that individuals laid their eggs in large masses in ponds, in contrast to the singly laid, terrestrial condition described by Combs. It is possible that Combs was observing an atypical behavior pattern of this species.

Collections and Acknowledgements

The following material is in the preserved collections of the University of Arkansas Department of Zoology.

ARKANSAS, Garland Co.: Adair Farm, 3 miles northwest of Buckville, May, 1939 (UADZ 227). Madison Co.: 2.3 miles northwest of Hindsville, pond on Highway 68, June, 1955 (UADZ 1637). Washington Co.: hillside 7 miles northeast of Fayetteville, October, 1953 (UADZ 598). Seven miles northeast of Springdale, White River and Highway 68, May, 1953 (UADZ 703). Five miles east of Mt. Gaylor, May, 1953 (UADZ 704). Church Pond, 8 miles northeast of Fayetteville, February, 1953 (UADZ 723), October, 1953 (UADZ 1217). Oxford Pond, 7 miles northeast of Fayetteville, October, 1954 (eggs; UADZ 1362).

The writing of this paper would not have been possible without the able assistance and kindly prodding of Herndon G. Dowling.

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CARAPACE PITS IN THE THREE-TOED BOX TURTLE, TERRAPENE CAROLINA TRIUNGUIS (CHELONIA-EMYDIDAE)

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ABSTRACT. Specimens of *Terrapene carolina triunguis* in a large population near Norman, Oklahoma, exhibited the presence of carapace pitting, involving both horn and bone, which was associated with the anterior border of the third costal scutes. Pitting was more abundant in females, with an increasing tendency to be present, in both sexes, with increasing carapace length. The cause of this pitting is not known.

While recording scute and other variations of a three-toed box turtle (*Terrapene carolina triunguis*) population, frequent note was made of peculiar pits on the carapace. The persistent occurrence of these pits and their consistent location at certain positions on the carapace led me to keep records of the presence and degree of pitting.

The carapace of the three-toed box turtle very frequently has scars and other irregularities, but these marks are not consistent in their appearance nor restricted to a particular region of the carapace. The carapace pits, with which this paper is concerned, are almost invariably associated with the suture between the second and third costal carapace scutes on either side of the carapace. They are usually either in the groove of the suture line or immediately posterior on the anterior margin of the third costal scutes. Only very rarely have similar pits been found near or in other carapace scute junctions. They are confined to the central half of the suture area between the junction with the marginals and the vertebrals (Fig. 1).

The size and structure of the pits is variable, ranging from only slightly distinguishable indentations to extremely obvious holes penetrating deep into the carapace. The small pits merely appear on the horn of the scute, but the deeper ones penertate into the bony plates of the carapace so that these bones also show the pitting. The horn of the scute lines the pit down into the bone. The pits may be present on only one side, but are generally on both sides. The arrangements of pits on both sides show no tendency for bilateral symmetry. The number of pits will vary from one to as many as seven or eight on a side.

The population of *Terrapene* studied is found on the Oliver Wildlife Preserve of the University of Oklahoma, 2 miles south of Norman, Cleveland County, Oklahoma. The preserve is a 60 acre plot of flood plain forest along the South Canadian River. Other species of turtle

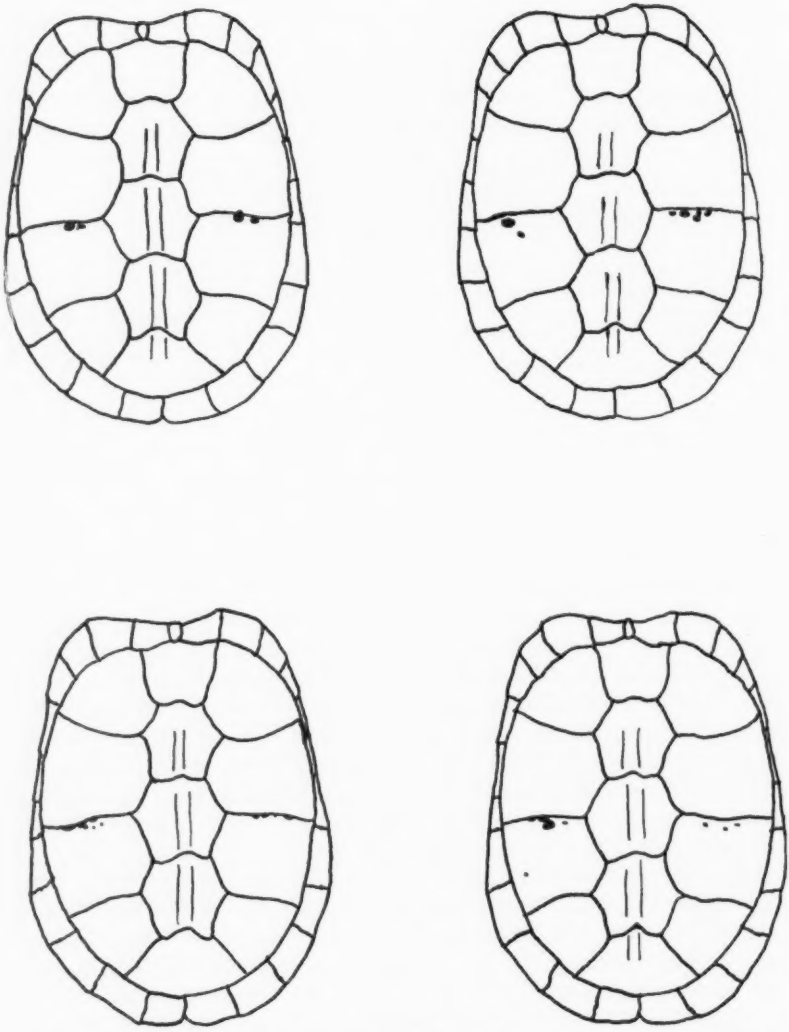

Fig. 1. Some variations in carapace pits of *Terrapene carolina triunguis* near Norman, Oklahoma.

Carapace Length (cm.)	*Number of individuals without pits*	(%)	*Number of individuals with pits*	(%)
4.0 — 4.9	0	0	0	0
5.0 — 5.9	1	(100%)	0	0
6.0 — 6.9	1	(100%)	0	0
7.0 — 7.9	19	(100%)	0	0
8.0 — 8.9	33	(100%)	0	0
9.0 — 9.9	34	(100%)	0	0
10.0—10.9	35	(95%)	2	(5%)
11.0—11.9	41	(60%)	27	(40%)
12.0—12.9	29	(28%)	74	(72%)
13.0—13.9	7	(11%)	56	(89%)
14.0—14.9	0	(0)	12	(100%)

Table 1. Relationship between pitting and carapace length for *Terrapene carolina triunguis* near Norman, Oklahoma.

present on the preserve are *Terrapena ornata, Kinosternon f. flavescens, Chelydra s. serpentina* and *Pseudemys scripta elegans*. None of these showed the pitting apparent for *Terrapene carolina triunguis*.

Four hundred and sixty living individuals of *T. carolina triunguis* have been captured and marked on the preserve since July 1953. Additional records have been obtained from frequent shells of dead individuals also present on the preserve. Recording of the pits did not start until late 1954, so that many records were missed. However, a large number of individuals marked before this time were later recaptured and the pitting recorded. The presence or absence of pits was recorded for 312 living individuals, and 63 shells, or a total of 375.

Of the 375 individuals examined 174 (46%) had pits present and 201 (54%) had no pits. Of those with pits, 147 (84%) had pits on both sides, 20 (12%) had pits on the right side only, and 7 (4%) had pits on the left side only. Six individuals also had pits at the area of junction of costals one and two.

The smallest individual for which pits were recorded was 10.83 cm. (carapace length). Three hundred sixty two of the 375 were sexed (sex determination is subject to error due to their great variability, but the errors would probably be equal for the two sexes). Of the 200 males, 66 (33%) had pits and 134 (67%) were without pits; of the 162 females, 100 (62%) had pits and 62 (38%) were without pits.

When the presence of pitting is compared to turtle age (assuming that carapace length is an expression of age) a definite trend is seen (Table 1). There is a continuous increase in the proportionate numbers if individuals with pits as the carapace becomes longer. The largest individuals all have carapace pits present. This trend certainly appears to be significant. Another feature, apparent with growth in size, is an increase in the definition of the pits, the deepest and most numerous pits being present on the largest individuals.

The pitting is not limited to the population of *Terrapene* on the Oliver Wildlife Preserve, for I have observed it on specimens from widespread areas of Oklahoma.

The cause of the carapace pits is not known. No mention of them has been found in the literature concerning this turtle or its eastern races. Possible causes are many, but none seem to be satisfactory explanations. Some pits appear as though parasitic fungi might have been present and the infected area later healed, but others do not seem to fit this theory. It was thought that perhaps a parasitic mollusk or some other invertebrate might be causing them, but there is no evidence to support this. Because of their inconsistency in being present and variation in position with respect to the suture line, it does not seem likely that they are genetic. The most logical cause might be erosion of the shell. When those pits associated with deep sutures are examined, they often appear to be due to this, yet others, in which the sutures are very shallow and the sculpturing of the carapace is very slight, may show very deep pits 1 to 2 mm. posterior to the suture line. It was thought that the damp retreats and hibernacula used by these turtles might have some relationship, but there is no proof of this.

From the evidence indicated by the population at the preserve, there is obviously some relationship to the size of the carapace. The evidence that they are slightly more frequent in females is not conclusive, and there probably is no direct correlation between sex and pitting. The fact that almost half of the induviduals in the population, and by far the great majority of the adults, have these pits, does not indicate accidental occurrence.

At the present time it is apparent that some causal factor is responsible for the pitting of the carapace, and that this pitting is related to certain positions on, and the size of, the carapace. No conclusion has been reached as to what this caudal factor, or factors, may be.

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NOTES

NEVIUSIA ALABAMENSIS GRAY (ROSACEAE) IN ARKANSAS.——On April 24, 1955, Mr. Marvin Lawson called the writer's attention to some strange shrubs growing on a low sandstone ridge about 6 miles northwest of Conway, in the southeastern section of Conway County, adjacent to Faulkner County. These were growing in some quantity for about 200 yards along the ridge. Specimens were collected, and though past the main blooming period, were easily identified as *Neviusia alabamensis* in Small's *Manual of the Southeastern Flora* (1933). Search in the University of Arkansas Herbarium revealed four other sheets collected in 1925 by D. Demaree along the cliffs above Cove Creek, in the northern part of Faulkner County, and identified then as *Physocarpus*. For sixty years after its first discovery in 1857, *Neviusia* was know as a monotypic, endemic genus of northern Alabama, where it has been reported from four counties (Jackson, Madison, Morgan, Tuscaloosa; cf. R. M. Harper, Geol. Surv. Ala. Monogr. 9: 194-196, 1928). In 1918, Dr. J. C. Th. Uphof found a single plant about 8 miles west of Poplar Bluff, Butler County, Missouri. The find was reported in a German publication (Mitt. Deutsch. Dendrol. Ges. 1921: 282-283), but the specimens unfortunately were destroyed. Uphof's illustration of his plant leaves little doubt as to the correctness of his identification. Search in July, 1955, west of Poplar Bluff, failed to reveal any evidence of the plant. This is not surprising, considering the changes of roads, fields, and other marks of "civilization." Search for the plant at its blooming time in the spring of 1956 was fruitless. A more extensive account of the species, with map and bibliography, has appeared in *Rhodora*, vol. 58, pp. 187-191 (July, 1956).—*Dwight M. Moore, University of Arkansas, Fayetteville.*

FORESTIERA AUTUMNALIS BUCKLEY (OLEACEAE) IN EASTERN TEXAS AND WESTERN LOUISIANA.——Though adequately described as long ago as 1863 (Proc. Acad. Nat. Sci. Phila. 14 (1862) : 7), from "Eastern Texas and Western Louisiana," this very distinct species has never been included in any flora or list. It was redescribed in 1943 as *F. Wrightiana* Lundell, Amer. Midl. Nat. 29: 487-488. A shrub or very small tree, the plant greatly resembles *F. pubescens* Nutt. in general appearance. It can be distinguished vegetatively by the leaf blades, which at maturity are soft-pubescent beneath but glabrous above except along the midrib. In *F. pubescens* var. *pubescens* they are similarly pubescent on both surfaces; in the doubtfully distinct var. *glabrifolia* Shinners, Field & Lab. 18: 99, 1950, they are glabrous on both surfaces. The most striking peculiarity of *F. autumnalis* is the fact that it flowers in late summer and fall (July-September); the fruits, ripening in fall, are globose, on pedicels 1—2 mm. long. *F. pubescens* flowers very early (January-March), before the leaves expand; the fruits, ripening in early summer, are globose-ovoid, on pedicels 2—7 mm. long. *F. autumnalis* is frequent in the Pine Belt and adjacent Oak Belt of eastern Texas (specimens in the S.M.U. Herbarium from Brazos, Freestone, Grimes, Harris, Madison, Montgomery, Newton, Panola, Rusk, Shelby, and Walker counties). *F. pubescens* var. *pubescens* occurs from the Blackland Prairie westward, var. *glabrifolia* from Grand Prairie westward. The following collection completes the confirmation

of Buckley's original statements about *F. autumnalis*. LOUISIANA, Sabine Parish: 5 miles southwest of Many, *Shinners 20218*, 7 June 1955 (sterile).—— *Lloyd H. Shinners, Southern Methodist University, Dallas 5, Texas.*

HYPOCHAERIS GLABRA L. (COMPOSITAE) IN ARKANSAS AND LOUISIANA.——This dandelion-like Mediterranean annual, resembling a *Pyrrhopappus* but with rather broad, appressed outer phyllaries and lacking the dorsal apical appendage on the inner ones, has long been established in California and Oregon, and has been found as a waif in the northeastern United States. It has now appeared in the Gulf Southwest. The following collections are in the Herbarium of Southern Methodist University. ARKANSAS, Calhoun Co.: 5.3 miles south of Hampton, roadside, "abundant for ½ mile," *Shinners 19917*, 1 May 1955. LOUISIANA, Lincoln Parish: Dubach, low ground by highway, *Shinners 19980*, 1 May 1955. The sudden appearance in abundance of another European Composite, *Crepis pulchra L.*, in northeastern Texas, has been reported previously (Field & Lab. 23: 44, 1955). The flora of the Southwest has hitherto been remarkable for its small persentage of introduced species, but it evidently will not remain so for long. Much of the region is chartcterized by open associations rather than closed climaxes, and is open to permanent colonization by exotic species, whether deliberately introduced range grasses or accidentally introduced weeds. The behavior of these exotics in the wild is of great ecological and evolutionary interest, and warrants close attention. (Cf. Shinners, "Geographic limits of some alien weeds in Texas," Texas Geographic Mag. 12 no. 1: 16-25, 1948).—— *Lloyd H. Shinners, Southern Methodist University, Dallas 5, Texas.*

WIND A FACTOR IN FLORAL ECOLOGY AND MORPHOLOGY.—Desert willow, *Chilopsis linearis* (Cav.) Sweet (Bignoniaceae), is widely planted along highways in western and southwestern Texas, chiefly by culverts or bridges. During summer it is often the most prominent and sometimes the only showy-flowered plant in bloom, attracting great numbers of insects. The majority of these are Hymenoptera, ranging in size from the great *Pepsis* wasps down to diminutive halictine bees *(Lasioglossum)*. High winds are characteristic during the day in these arid and semiarid sections. Even strong fliers like bees of the genera *Anthophora, Hemisia, Melissodes,* and *Xylocopa* can be seen struggling vainly to make headway against strong gusts, then coasting off downwind to another plant, seeking the openings of the large blossoms, which the wind turns to leeward. Small bees make short trips when flight is possible, lighting where they can on the outside of a flower, then crawling around to the opening. Once inside the large 2-lipped funnelform-campanulate corolla, the insects are temporarily sheltered. Visits in one blossom are apt to be prolonged (ideal for the collector, who can slip a killing jar over the flower when it is not too violently wind-tossed and make a sure catch), undoubtedly in part because of relief from the wind. A corolla is generally thought to serve as protection for nectar and reproductive parts inside, and in addition to attract and to provide a landing platform and guide for visitors. Shelter for insects also may be of considerable importance. The great diversity in size among the visitors indicates that whatever adaptation there may in the corolla of *Chilopsis*, it is not precise and certainly not exclusive for any particular insect.

A comparable illustration is afforded by the common sunflower, *Helianthus annuus* L. (Compositae), in much the same general region as *Chilopsis* and a little farther east. Contrary to Blake's famous poem, the heads during the

summer face away from the sun, not toward it, even at times when the prevailing southerly winds are not strong enough to tip them northward. Purpuseful or not, this behavior means that the open florets are partly shaded and (doubtless aided by evaporation from the enormous surface-area exposed by the many individual flowers in the head) relatively cool. On the driest and hottest days of summer, individuals of the very common bee *Diadasia enavata* and one or two species of usually alert and swift *Melissodes* can be found resting sluggishly on the disk at the base of the ray florets. In windy weather, the rays (which produce no pollen) clearly serve as a partial windbreak, making it easier for flying insects to approach and land on the disk. Thus the structure of the sunflower head not only assists visitors to alight, but in addition shelters them against extremes of sun and wind, insuring the survival of a supply of pollinators for milder times.

Here are two quite dissimilar yet parallel examples to show that the relations between flowers and insect visitors are more complex than direct adjustments for the transfer of pollen. It is true that the suggested benefits are direct and continuous to stamens and pistil, while those to insects are relatively momentary and perhaps only coincidence. But in view of the fact that native bees and higher wasps are more numerous in genera and species (probably also in individuals) in the hot and windy environments of arid and semiarid regions, wind-protection may well have been a significant factor in the evolution of insectophilous flowering plants found in or derived from those regions.—*Lloyd H. Shinners, Southern Methodist University, Dallas 5, Texas.*

A CASE OF INFERTILITY IN A PAIR OF GOLDEN EAGLES (AQUILA CHRYSAETOS, AVES).—What is apparently the same pair of eagles has for the past three years produced only infertile eggs. This pair of eagles controls a nesting area containing nine nests on the U Lazy S Ranch south of Post, Texas. In 1954 an incubating bird was found on February 21. On March 29 the birds were still incubating but on April 3 the nest had been abandoned and the eggs were collected four days later. They were infertile. In 1955 the bird was found on about February 20 on a nest about 400 yards from the 1954 site. Two weeks later a flash rain filled the nest with mud and the eggs were abandoned. The eggs were taken two days later, blown, and found infertile. In 1956 the birds occupied a nest roughly 1000 yards from nest one and 600 yards from nest two. The eggs were first seen on February 12. On March 18 the bird was still incubating but on March 25 it had abandoned the nest. The eggs were taken on April 14 at which time one eggs was cracked but had lost none of its contents. Both eggs were blown and were found to be infertile.

During the same three years, six other eagle nests were found and at four of these, the bird was driven off the nest at the same or earlier dates than above mentioned. In all cases the eggs hatched. (The other two nests were found after the young had already hatched.) Hence, we do not believe that our driving the bird off the nest to see the eggs had any effect on their failure to hatch.

It is interesting to note that in each case the birds incubated for only the normal period, approximately six weeks. One cannot help but wonder how long this pair of birds has been mated, whether they have always laid infertile eggs, what is the cause of this infertility, and how long it will continue.

My sincere appreciation is due Mr. Robert W. Mitchell who was largely responsible for the 1954 and 1955 data.—*R. W. Strandtmann, Department of Biology, Texas Technological College, Lubbock.*

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REVIEWS

A REVIEW OF THE NEARCTIC VIBURNUM. W. L. McAtee. Chapel Hill, North Carolina. 1956. (Reviewed copy received at Dallas May 15.) Privately printed (author's address: 3 Davie Circle, Chapel Hill, N. C.). 125 pp. 8vo.; 9 pl.

This is a very remarkable little publication, for a number of reasons. Though a unique venture into the battle-scarred field of systematic botany by a zoologist, it is an accomplished revision of a difficult group. Spanning a period of half a century, the work was largely completed after retirement from long-term service with the federal government, and cost of publishing the results was borne by the author. It would be a mean and ungracious critic who did not voice heartfelt thanks and appreciation for the help thus received from what in our day is a most unexpected source. The antique tradition of the broad, general naturalist is not wholly dead after all.

The main part of the work consists of a systematic list of the named taxa, three keys (one based on general features but chiefly leaves, one on winter buds, one on stones and fruits—reflecting the writer's long interest in wildlife foods), a systematic account of species and varieties with full synonymy and detailed descriptions, comments on noteworthy variants not given nomenclatural recognition, dates of flowering and fruiting, and distribution by states or (for limits of ranges or outlying stations) by counties. There are three indexes: to accepted species, to synonyms, to vernacular names. The author accepts 22 species plus 14 varieties for the native representatives of the genus, with 3 species and 1 variety of exotics found wild. The acknowledgements and lengthy (9-page) list of references make it clear that much time and effort have been spent on the purely indoor phases of the work, including checking of publications and specimens at numerous institutions in both America and Europe. Though collections are not cited and there are no maps, the descriptions, notes on aberrant forms, and miscellaneous remarks show that the author has supplemented very extensive and intimate field acquaintance with an examination of a large quantity of herbarium material. One could wish that productions of avowed plant taxonomists were always as solidly based.

A minor annoyance arises from the fact that species are not numbered. Since they do not always come in systematic order in the keys, one must refer to the indexes or search the systematic list, or leaf through the pages in order to find the complete account of any paricular one. Some difficulv will be encountered in using the general key, which calls for both winter buds and foliage. It is a very respectable technical outline rather than a utility key. But since winter buds are necessary at only one point, it is quite usable. After identifying my Louisiana collections of the past spring, I rate it superior to the keys provided by Bailey and Rehder.

Another annoyannce to many, but a very minor one, will be the author's adherence to his own personal code of nomenclature, which is neither botanical nor zoological. It is interesting to see how little difference this makes. The varietal category is used in the orthodox botanical manner, but for purposes of priority, varieties and species are treated as if of equal rank, following the zoological handling of species and subspecies. Although the author declines to place his own name on new combinations, his citation of necessary synonymy and explicit statement of category make his new combinations valid, and nearly all are also legitimate. Plant taxonomists, following their Code of Nomenclature, will simply add McAtee's name in the appropriate places. The following new names must be accepted: VIBURNUM affine var. australe (Morton) McAtee, V. acerifolium var. ovatum (Rehder) McAtee, V. acerifolium var. densifolium (Chapman) McAtee, V. Indianemse (Rehder) McAtee, V. carolinianum var. Deamii (Rehder) McAtee, V. scabrellum var.

Ashei (Bush) McAtee, V. scabrellum var. venosum (Britton) McAtee. In three cases the author citation is not given with the second author, as prescribed by the Code: V. edule (Michx.) Raf., V. pubescens (Ait.) Pursh, V. scabrellum (T.&G.) Chapm. In another three cases, the criss-cross priority has resulted in 3 new combinations which are illegitimate: *V. cassinoides* var. *nitidum* (Ait.) McAtee=*V. cassinoides* var. **angustifolium** (T&G) Shinners, comb. nov. (based on *V. nudum* var.*angustifolium* T.&G., Fl. N. A. 2: 14, 1841); *V. grandifolium* (Ait.) MsAtee=V. lantanoides Michx.;*V. Opulus* var. *trilobum* (Marshall) MsAtee=V. Opulus var. americanum Ait. (Hort. Kew. 1:373—not 168, as cited; this name not based on *V. americanum* Mill., but described as a new and independent taxon). If we consider that author citations are not an integral part of a scientific name, but something added for convenience or helpfulness (which may ultimately be dispensed with), we find that strict adherence to botanical rules of nomenclature requires only three substitutions of names out of 40 accepted by McAtee. Truly an impressive demonstration that adherence to the rules may promote stability rather than the reverse! Perhaps it demonstrates too that sound taxonomy begets sound nomenclature. In any case, one would be unrestrainedly grateful for more such works as this even with much worse nomenclature.

It is refreshing to find an author who is unafraid of principles or the consequences of following them. His views on nomenclature are simple and sensible—strict priority, no admission of exceptions or special rulings by committees or congresses, no sharing of credit between original discoverer and later authors. The results of adhering to these beliefs are not so bad when only one genus is taken up, even though it is a fairly large and much-named one. But on the scale of a whole flora, with thousands of species and varieties matters are not quite so simple. It does not take long to discover that the number of examples that can make the rules look ridiculous is really a quite small and excessively publicized minority. The rules prove much more workable and beneficial than they appear from limited acquaintance. I do not think McAtee's code better than the international one, for quite practical reasons. The differences are after all remarkably small, as shown in the nearly identical results with regard to *Viburnum*. We have had a quite stable set of botanical rules for better than a quarter of a century—not long enough to bring all names into order, but long enough to give the rules a pretty thorough tryout, and to become accustomed to them. We cannot by any retroactive magic convert all older publications into code-following ones. Charles Robertson justly remarks (*Flowers and Insects*, 1929, p. 4), "Anyhow, biological nomenclature is synonymical, not binomial. The older names usually have more important relation to .... literature." It requires much time and effort, extensive bibliographic facilities, and a reasonable taxonomic understanding to deal effectively with our staggering accumulation of names, synonyms, and misapplications. Our rules would be quite adequate for dealing with this colossal task if there were more people willing and able to take the trouble necessary to follow them.

But this is digression. It is easy to ramble on about nomenclature, which is only a bothersome but necessary means to enable us to refer to, and make usable, information of more substantial value. A good taxonomic treatment is apt to be more used than talked about. It is satisfying rather than exciting, useful rather than conroversial. McAtee's review is of this kind. Short of cytological and experimental work, not much more could be done to provide an adequate taxonomic summary of the North American species of *Viburnum*. Triple thanks to the author for a welcome piece of work, for his personal sacrifices in making it available to us—and for the reminder that worship of the sacred cow of conformity in trivialities is neither necessary for, nor automatically productive of, good taxonomic work. —*Lloyd H. Shinners.*

CHECK-LIST OF THE BIRDS OF TEXAS. Col. L. R. Wolfe. Intelligencer Printing Company, Lancaster, Pennsylvania. 89 pp., folding map. 1956. $1.75.

This is the first summary of records of occurrence of the Recent birds of Texas to appear since Strecker's annotated check-list in 1912 (Bull. Baylor Univ., 15). The present list is a compilation of records from the literature and from unpublished county or regional check-lists, and includes, in addition, some hitherto unpublished records from the files of the U. S. Fish and Wildlife Service. Technical nomenclature is that of the American Ornithologist's Union Check-List, Fourth Edition, (1931) and Supplements; subspecific vernaculars are not employed. For reference purposes the state is divided into eight regions, shown on a map, and distributions are indicated largely in terms of these regions. The text is well organized, attractively printed, and all but free of typographical errors.

Basis for inclusion of a species in the list is the existence of a specimen to substantiate its occurrence in Texas, "except in a few cases where the identity was authenticated sufficiently to eliminate any question of doubt." With respect to subspecies this rule seems not to have been so strictly applied. For example, the Central American race of the Limpkin *(Aramus guarauna dolosus)* is included although its occurrence in the state is not firmly established, and *Branta c. canadensis* is given status even though the author expresses doubt that it "occurs at all in Texas."

The principal defect of this work is that it is based on an incomplete perusal of the literature; even the leading ornithological journals apparently were not systematically examined. Notably absent is any reference to a report of the birds of the central Panhandle by Stevenson (Condor, 44, 1942: 108-115) and to four important avifaunal studies published in the Texas Journal of Science since 1949, dealing with birds of the Sierra Vieja range, Presidio County, Stockton Plateau, northern Terrell County, Canadian "Breaks," Hutchinson County, and the Black Gap region, Brewster County. Papers by McLaughlin (Auk, 65, 1948: 180-188) and Parkes (Condor, 52, 1950: 91-93) on Taylor County apparently were not consulted. Information contained in these seven papers necessitates modification of statements of distribution and/or status of 84 species. There are records in the literature of at least 53 species and subspecies in the central and northern Panhandle which are not indicated as occurring there in the present list.

The usefulness of the list to ornithologists concerned with distributions of subspecies is limited by the author's failure to consult several recent revisionary studies, among these Davis' work on *Pipilo* (Univ. Calif. Publ. Zool. 52, 1951) and Wetmore's revision of *Centurus aurifrons* (Wilson Bull., 60, 1948: 185-186). Lack of documentation makes it difficult to judge the basis for inclusion of a few forms, such as *Spinus lawrencii*. Occasionally record sources are cited "second-hand." Thus Bent (Bull. U. S. Nat. Mus., 197, 1950: 78) is credited with the only record of the Bohemian Waxwing, a specimen from Randall County first reported by Stevenson (Condor, 44, 1942:114).

A few comments on Wolfe's comparison of total numbers of species in Texas and California are in order. Wolfe claims 740 forms and 522 species for Texas as compared to 644 forms and 427 species for California, citing Miller (in Grinnell and Miller, Pacific Coast Avi., 27, 1944:12). Actually the Texas totals are not strictly comparable with those for California, since the

latter do not include introduced or fossil forms or records based on sight identification alone, a circumstance made perfectly clear by Miller. To make the Texas count of species comparable, at least 13 species must be excluded, including introduced game birds, Cattle Egret, Starling, House Sparrow, California Condor, Purple Sandpiper, Varied Thrush, and Abert's Towhee. An additional "species" is lost by reason of the fact that *Parus atricristatus* is conspecific with *Parus bicolor* (Dixon, Univ. Calif. Publ. Zool. 54, 1955). The total number of species is reduced to 508. The latest count for California (data given by Miller, *loc. cit.* and Univ. Calif. Publ. Zool., 50, 1951: 619-620) is 429 species. The number of subspecies occurring in Texas cannot be judged accurately from the present list, which is incomplete in this regard.

Although its usefulness could have been improved by a more thorough study of the literature, the present list will be of value to everyone concerned with the birds of Texas.—*Robert K. Selander, Department of Zoology, University of Texas, Austin 12.*

Career Opportunities in Biology. The Challenge of the Life Sciences. Russell B. Stevens. Row, Peterson and Company, 1911 Ridge Avenue, Evanston, Illinois. 1956. 48¢ (less 25% school discount, plus postage). Quarto size, paper cover. Prepared under sponsorship of the National Academy of Sciences—National Research Council.

I opened this brochure with apprehension and laid it down with a shudder. It repudiates scientific method in an attempt to recruit, on a mass scale, not scientists but parasites of science. It adopts the techniques of modern American advertising—cartoons, folksy style, appeals to self-interest and vanity, charts and statistical tables whose validity and relevance will hardly stand under sharp scrutiny. It gives no hint of two prime needs in a scientist: a sense of obligation and a readiness to make sacrifices. Its greatest appeal will surely be to those of shallow mind, amorphous character, and selfish inclination.

The circumstances which occasion this booklet are phenomena of human history. We ought then to learn first as much as we can of the patterns of history, assemble data not only from within the field of immediate concern but from parallel ones as well, and try to arrive at some understanding of what is going on. Dr. Stevens' charts and tables give the illusion that something of the kind has been done, but in reality they have no bearing on origins or causes, and very little on remedies. Is there not proceeding before our eyes a simple ecological succession, utterly uncomprehended by those whom it most involves? We have progressed from pioneer discovery by small numbers of dedicated amateurs to elaboration by large numbers of specialists. There have been opened up vast fields of employment for masses with "trained incapacity" (the phrase is quoted by Harvard's Pitirim A. Sorokin in *The Crisis of Our Age*, New York, 1941). The scientist in what Toynbee already has called our post-modern world is productive where his predecessors were creative. They produced and moulded and mastered their science; he is its servant. We have reached the stage at which cramping specialization and the deadly routine of fact-cramming that comprises training for science have so damaged any natural attraction that we stoop to advertising to recruit personnel. Compulsion lies only a step or two beyond. Indeed compulsion of

a kind already has begun. C. Wright Mills declares bluntly that American science now is subject to economic, military, and political forces to such a degree that it does not and cannot control its own destiny (*The Power Elite*, Oxford University Press, 1956). His assertion may be modified by citing the extent to which science has provided occasions and means, but this is only ironical embroidery; it refutes nothing. Science then is subject to both inward and outward influences of which scientists themselves are ignorant, and being ignorant, cannot manage.

The failure of science in the management of human affairs was bitterly commented on a decade ago by Hans J. Morgenthau (*Scientific Man vs Power Politics*, University of Chicago Press, 1946). Still earlier Toynbee had warned against treating human history as if it could be handled by the same techniques used in science or industry (*A Study of History*, introduction to vol. 1; Oxford University Press, 1934). But science at bottom is mainly care and common sense, and I reject the idea that science can do nothing to influence human history in a conscious, purposeful, and desirable way. Propaganda, however, is not science. Had Dr. Stevens approached his task in the way obviously indicated for any sound scientific or scholarly work, he would very quickly have come up with information that is utterly unpalatable, and whose publication would have been refused by editors of national journals. This is not mere conjecture: it has been exactly my own recent experience. But it is not prevision of this I am sure which led Dr. Stevens to write as he did. American scientists are simply not able to think historically. Their failure to foresee present conditions is one proof; the crudity of their belated efforts to do something is another. Dr. Stevens' brochure is slightly less saturated with fallacy and error than some similar publications (as one extreme example, see K. Starr Chester, "National requirement and availability of botanists," Amer. Journ. Bot. 34: 240-243, 1947), but it is bad enough. Let me comment on two conspicuous items.

There is the first simple fallacy of treating biology as if it were a single science, and as if the different endeavors miscegenously put under it could all be discussed on par. Each special study fluctuates, has its ins and outs, its rises and depressions, and each has its own time-periods which do not coincide with those of most other fields. Plant taxonomy, for example, is now well on the rise from a trough in what apparently is to be a cycle of some 80 to 100 years from peak to peak. Younger sciences (ecology, for example) have different periods, and periods which hold in Enrope may not be the same in America or elsewhere. Considered in comparison with the physical sciences, all the biological sciences are in a depressed phase, despite many individual peaks among them. We know almost nothing of how or why such fluctuations happen, and we cannot do intelligent planning merely by counting noses and plotting graphs for unsorted samples. Changes within science do not obey laws of supply and demand, still less those of commercial advertising.

Generalized propaganda on behalf of biology brings to mind the introductory remark in Will Earhart's *Music to the Listening Ear* (New York, 1932): that if you listen for nothing in particular, that is what you will hear—nothing in particular. So in attempting to attract a student's interest you cannot get far with a catch-all brochure—nor with a general introductory course. (I have figures of enrollments before and after integration of courses, and resulting majors, which back up this statement—but I cannot make

them public without rousing censure and violent hostility among supposedly objective American scientists.) Botany is botany and zoology is zoology, and never the two should meet until well beyond or outside an introductory college course. Even each by itself is too large to approach first as a whole. I flatly reject the universal misconception that one must survey everything first and specialize afterward: there is no historical backing for it. (Again I touch a point which it is not safe to elaborate.)

There is a second and more dismal fallacy in the statistics supposed to show future numbers of students, teachers, and so forth. It is taken for granted that what is being dealt with is, if not uniform, near an acceptable average, and that the same will be true in the future. There is no awareness of the cultural trends of our century, nor the social and psychological consequences of large and increasing populations. Over twenty years ago José Ortega y Gassett wrote of the "mass-mind" (*Revolt of the Masses*, New York (English translation), 1932). More recently the same phenomenon has been described for America in particular as the "other-directed" personality by David Riesman (*The Lonely Crowd*, Yale University Press, 1950). This changing bias, apparently inherent in simple increase in numbers, has been compounded by American "progressive" education. How can we gauge the efficiency or adequacy of the next generation by plotting census figures? Even supposing the charts and statistics are valid (I insist they are not), will we attract the best students to science by tabulating income, security, prestige, by talking of benefits and advantages to self, or of the need of the masses for more education. I hope not, and I believe not. There is a certain baseness in holding out appeals of whatever kind if we do not point out the darker sides of the picture. Are we not more likely to attract those of superior character and intellect by outlining the difficulties and complexities of our times? The real challenge of modern biology lies not within itself, but in its relations to the historical changes of our age. We may not attract some quartile of every incoming freshman class, but surely we will those most worthy of the traditions of Western science, and most likely to benefit it in the years ahead. Those who argue that to reach American youth we must use the advertising techniques with which they are familiar betray a poor estimate of those they seek to attract. I do not believe it is true that this is the needed approach to most or even many of those intending to obtain a college education. Certainly it ought not to be true for those who are to become tomorrow's scientists, and it must not be true if science is not to become so degraded that it ceases to be science.

Career Opportunities in Biology is a symptom, not a remedy. No one with any historical perception can render as judgment on it anything but fervent damnation, nor predict anything but eventual failure in its purpose. The optimistic may hope that the witless drifting of American science, paced by its mass organizations, hostile to criticism or non-conformity, ignorant of the dynamics of history, naive in its attempts at social action, resorting more and more to methods that are not proper to science and are even hostile to it, might be stopped or at least altered. But optimism is never objective — *Lloyd H. Shinners.*

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